DEFENCE R&D DÉFENSE

Chemical and Biological Warfare Agents
An Introduction for First Responders

C.A. Boulet, S.J. Armour, L. Schofield, A.F. Burczyk, P. Lecavalier,
B.V. Kournikakis, R.G. Clewley, R.W. Bide and R.K. Harding
Defence Research Establishment Suffield
Box 4000, Stn Main
Medicine Hat, Alberta T1A 8K6

WARNING

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DEFENCE RESEARCH ESTABLISHMENT SUFFIELD

Special Publication
DRES SP-200

November 1999

National Defence Défense nationale

Canada

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD
RALSTON, ALBERTA

SUFFIELD SPECIAL PUBLICATION
NO. 200

CHEMICAL AND BIOLOGICAL WARFARE AGENTS
AN INTRODUCTION FOR FIRST RESPONDERS

by

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R.G. Clewley, R.W. Bide and R.K. Harding

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ACKNOWLEDGEMENTS

The authors wish to thank LCol Paul Morneault, Directorate of Nuclear, Chemical and Biological Defence (DNBCD), for the opportunity to present the seminar "Chemical and Biological Warfare Agents: An Introduction for First Responders" as the scientific/technical portion of the first responders CB counter-terrorism training program organised by DNBCD. The efforts of the National Capital Region First Responders Team in organising the training session is gratefully acknowledged.

The assistance of the following DRES staff members is gratefully appreciated: Shelly Ewing for designing the seminar cover, Ruth Letersky, Carol Roseveare, Chris Brownlee in preparing the viewgraphs and seminar material and Dave Coward in cutting the CD-ROMs.

The authors also would like to thank Dr B. Garrett, Battelle Corp., for the photograph of Dr Schrader; Dr Andrew Shuttleworth, CBD Sector Porton Down, for the photographs of Dr Schrader and his laboratory; and LCol T. Cieslak, USAMRIID, for the Sverdlovsk autopsy slides.

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101-02867/

ABSTRACT

The Defence Research Establishment Suffield has developed a pilot seminar "Chemical and Biological Warfare (CBW) Agents: An Introduction for First Responders" at the request of the Directorate of Nuclear, Biological and Chemical Defence (DNBCD). This seminar consist of nine modules; Introduction, Canadian CB Defence Program, History of CBW, Chemical Warfare Agents/Industrial Chemicals/Toxins, AUM Shinrikyo – CB Terrorism, Biological Warfare Agents, The Attack, A BW Terrorist Attack on a Major Canadian City and Management of a CB Incident. The seminar was presented 23-25 August 1999 as the scientific/technical portion of a chemical and biological counter-terrorism training package provided to the National Capital Region First Responders Team. The seminar is available in both printed and CD-ROM formats.

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Section 4: Chemical Warfare Agents, Industrial Chemicals and Toxins

Section 5: AUM Shinrikyo; Chemical and Biological Terrorism

Section 6: Biological Warfare Agents

Section 7: The Attack

Section 8: Hogtown Disaster: A Biological Terrorist Attack on a Major Canadian City

Section 9: Management

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9b: Detection and Identification of Biological Warfare Agents

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9d: Personal Protective Equipment and the Chemical Warfare Agent Contaminated Environment

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PREFACE

The Defence Research Establishment Suffield (DRES) has a long history of providing chemical and biological defence (CBD) training for the Canadian Forces (CF). Both the Land Forces Technical Staff Program and the Advanced Nuclear Biological Chemical (NBC) Defence Staff Office Course visit DRES annually for lectures, laboratory sessions and decontamination field exercises using "live" chemical agents. Exercises and specialized training are provided each year for the Canadian Nuclear, Chemical and Biological Response Team. DRES staff also lecture regularly on CBD topics at CF NBC School at Camp Bordon.

Consequently, when LCol Paul Morneault, Directorate of Nuclear, Biological and Chemical Defence (DNBCD), requested that DRES join with DNBCD in providing CBD counter-terrorism training for First Reponders, DRES accepted and prepared a pilot CBD siminar. This seminar, "Chemical and Biological Warfare (CBW) Agents: An Introduction for First Responders", was delivered in Ottawa 23-25 August 1999 to the National Capital Region First Reponders Team.

This Suffield Special Publication is a record of the pilot seminar presentations and is available in both printed and CD-ROM formats. It is being made available at this time in reponse to requests for copies of the CD-ROM from both Canadian and allied groups.

DEFENCE R&D DÉFENSE

Chemical & Biological Warfare Agents

An Introduction for First Responders

Presented by:

Defence
Research
Establishment
Suffield

Chemical &
Biological
Defence
Training
Team

National Defence / Défense nationale

Canada

Section 1:

Chemical and Biological Warfare Agents: An Introduction for First Responders

DEFENCE R&D DÉFENSE

Chemical and Biological Warfare Agents

An Introduction for First Responders

presented by

Defence Research Establishment Suffield

Chemical and Biological Defence Training Team

Canada

DRES

DRES Chemical and Biological Defence Training Team

Trainers

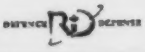
Camille Boulet
Andrew Burczyk
Laurie Schofield
Joan Armour
Pierre Lecavalier

Contributors

Robin Clewley
Richard Bide
Robert Angus
Murray Hamilton
Thor Jacobson
Garfield Purdon
Bill Koumikakis
Carol Roseveare
Shelley Ewing
Capt Roger Tremblay
Kent Harding

Seminar Objective

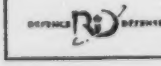
To provide the basic information and background to enable First Responders to effectively manage a chemical or biological incident.



Seminar Schedule

Monday, 23 August 1999

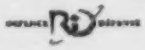
1300-1315	Introductions and Training Objective
1315-1400	The Canadian CB Research Program at the Defence Research Establishment Suffield
1400-1430	CB Warfare: A Centuries Old Problem
1430-1500	Coffee
1500-1600	The Chemical Hazard
1600-1630	Discussion



Seminar Schedule

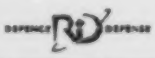
Tuesday, 24 August 1999

0900-1000	Case Study 1: AUMShinrikyo
1000-1020	Coffee
1020-1130	The Biological Hazard
1130-1200	The Attack
1200-1300	Lunch
1300-1400	Case Study 2: Hogtown Disaster
1400-1500	Consequence Management
1500-1520	Coffee
1520-1600	Consequence Management (cont'd)
1600-1630	Wrap-up



Seminar Message

- Well informed, trained, and equipped **First Responders** are the most effective defence against chemical and biological terrorism.
- **You are the first line of defence!**



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Section 2:

The Canadian Chemical and Biological Defence Research and Development Program

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DEFENCE R&D DÉFENSE

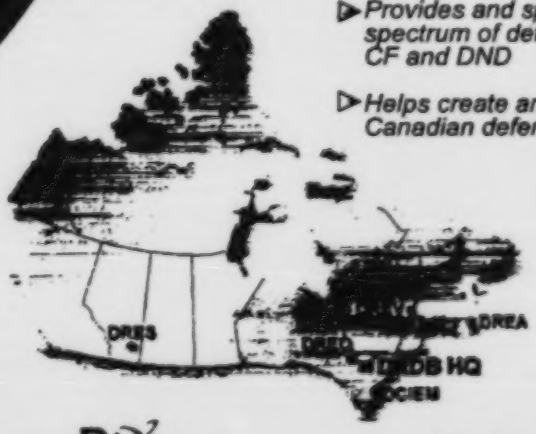
The Canadian Chemical and Biological Defence Research and Development Program

Dr Camille A. Boulet
Head, Hazard Avoidance Section

Canada

Defence R&D Branch

- *Provides and sponsors a broad spectrum of defence R&D for the CF and DND*
- *Helps create and maintain the Canadian defence industrial base*



DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

Defence Research Establishment Suffield (DRES)

- Established in 1941
- Continued defence R&D since 1941
- Currently 141 staff (~60 CB defence)
- Lodger unit on CFB Suffield
- Importance of the Suffield Block

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

Current R&D Focus

- ***Chemical & Biological Defence***

  Detection, Protection & Medical Countermeasures

- ***Combat Engineering***

  Mine Detection, Countermine, Land Robotics

- ***Humanitarian De-mining***

  Canadian Center For Mine Action Technologies (CCMAT)

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

Mandate of the

Chemical and Biological Defence Program

- Conduct R&D in Chemical and Biological (CB) Defence as foundation for undisputed expertise and leadership
- Provide technical expertise and support to the Canadian Forces (CF) and Other Government Departments on CB Defence issues
- Develop the best CB Defence equipment for the CF
- Support Canadian industry partners in pursuing international opportunities for Canadian CB Defence equipment and expertise

DEFENCE R&D DÉFENSE

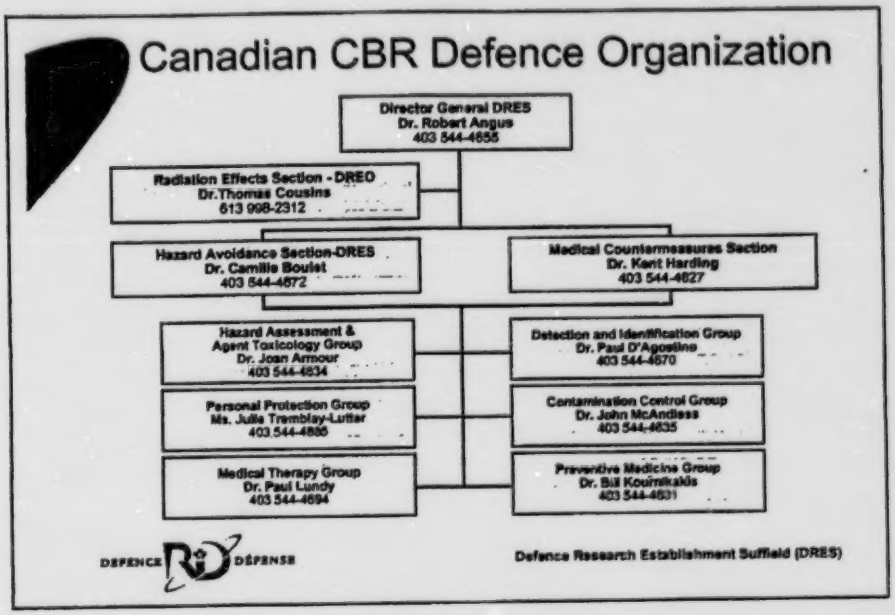
Defence Research Establishment Suffield (DRES)

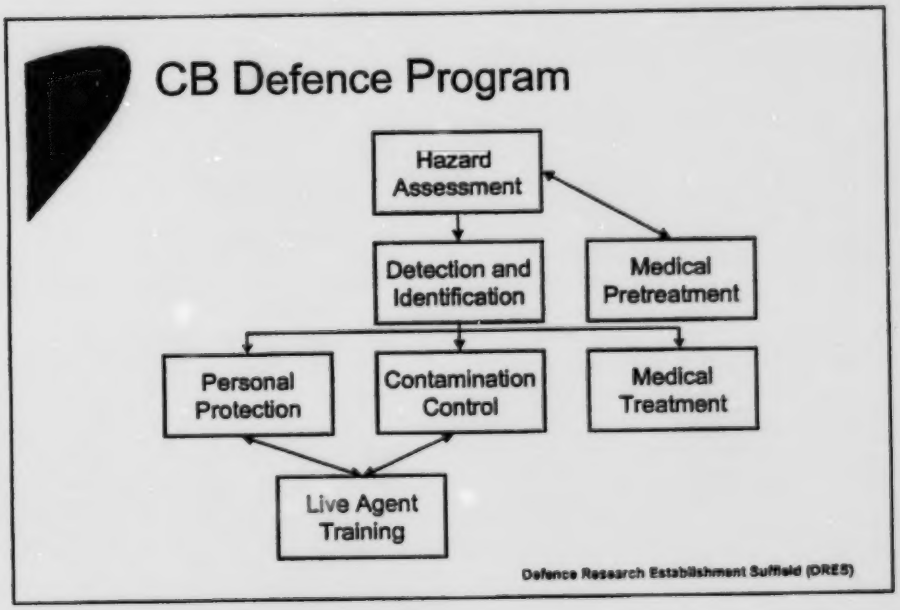
Main CF Clients

- Surgeon General Branch (CFMG)
  - Primary customer for experimental therapies, advice on risk and risk reduction
  - Assistance in regulatory approval for medical countermeasure
- Directorate Nuclear, Biological and Chemical Defence (DNBCD)
  - Target for products to reduce operational impact of NBC Hazards

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)


Canadian CBR Defence Organization
Director General DRES
Dr. Robert Angus
403 544-4655
Radiation Effects Section - DREO
Dr.Thomas Cousins
613 998-2312
Hazard Avoidance Section-DRES
Dr. Camille Boulet
403 544-4672
Medical Countermeasures Section
Dr. Kent Harding
403 544-4627
Hazard Assessment & Agent Toxicology Group
Dr. Joan Armour
403 544-4634
Detection and Identification Group
Dr. Paul D'Agostino
403 544-4670
Personal Protection Group
Ms. Julie Tremblay-Lutier
403 544-4686
Contamination Control Group
Dr. John McAndless
403 544-4635
Medical Therapy Group
Dr. Paul Lundy
403 544-4694
Preventive Medicine Group
Dr. Bill Koumnakis
403 544-4631
DEFENCE R&D DÉFENSE
Defence Research Establishment Suffield (DRES)


CB Defence Program
Hazard Assessment
Detection and Identification
Medical Pretreatment
Personal Protection
Contamination Control
Medical Treatment
Live Agent Training
Defence Research Establishment Suffield (DRES)

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

Chemical R&D Facilities

- Canadian National Single Small-Scale Facility under CWC
  - synthesis and use of agents for permitted purposes
  - State-of-the-art chemical and biochemical analytical facilities
- Chemical Containment Labs
  - specialized handling and test facilities
- Field Training Site
  - live agent training

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

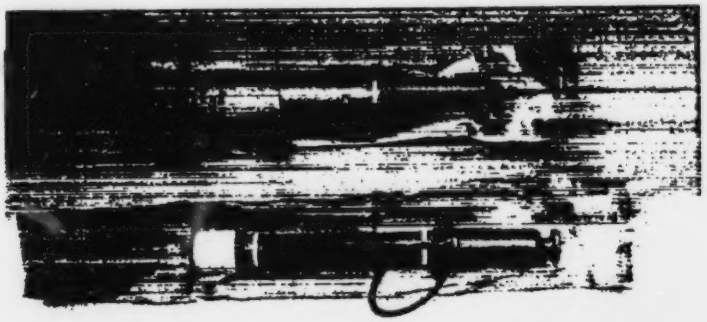
CA C4 Gas Mask and C7 Canister

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

HI-6 Autoinjector

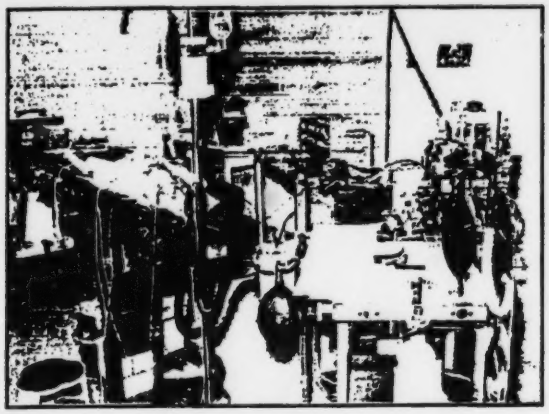
treatment of nerve agent poisoning
contains 500 mg HI-6 and 2 mg atropine



DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

Medical Management of Chemical Casualties



DEFENCE R&D DÉFENSE

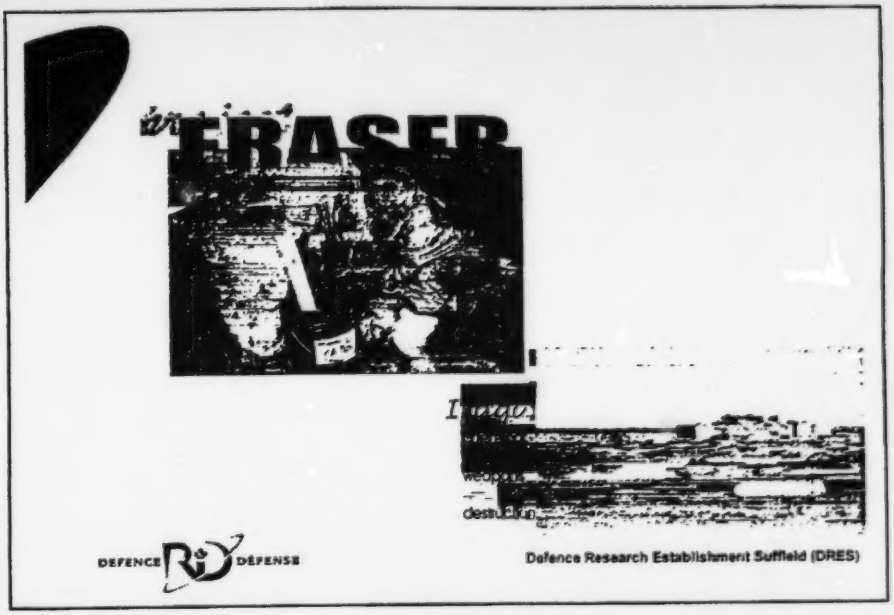
Defence Research Establishment Suffield (DRES)

Live Agent Training

CF Decon Exercise with *CASCAD*

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)



CB Program Role in Canadian Counterterrorism Domestic Preparedness

- DRES CA Centre for CB Technical and Operational Expertise
- Expertise and technology broadly-applicable to domestic preparedness
- Technologies represent markets and capabilities of interest to industrial partners
- Access to specialized training and test facilities including live agent training for first responders

DEFENCE R&D DÉFENSE

Defence Research Establishment Suffield (DRES)

Blast-Guard

Blast Suppressant CB Decontaminating Foam

DEFENCE R&D DEFENSE

Defence Research Establishment Suffield (DRES)

DRES Actions for Domestic Preparedness

- 1995 Tokyo subway attack investigation
- Hazard Assessment of toxic industrial gases as weapons of opportunity
  - CANSLAB dispersion model
- Canadian NBC Response Team
  - CB experts
  - Live agent training
- First Responder Workshops
- RCMP collaborative development of a blast suppressant, CB decon foam

DEFENCE R&D DEFENSE

Defence Research Establishment Suffield (DRES)

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Section 3:

Chemical and Biological Warfare: A Centuries Old Problem

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DEFENCE R&D DÉFENSE

Chemical and Biological Warfare

A Centuries Old Problem

Canada

DRES

Chemical and Biological warfare is the use of toxic chemicals or diseases to reduce or destroy the military effectiveness of man.

DRES

Belligerents have used chemical or biological warfare when they perceive a significant advantage in so doing!!!

DRES

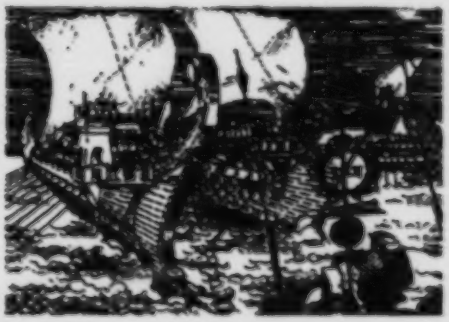
600 B.C.

Solon of Athens **contaminated** the **drinking water** of Kirrha with hellebore roots thus causing diarrhea.

429 B.C.

Peloponnesian War: While besieging Athens the Spartans burned sulfur and pitch creating clouds of **toxic** sulfur dioxide **smoke**.

184 B.C.



Hannibal hurled earthenware pots filled with snakes onto the decks of enemy vessels, **causing panic and confusion**.

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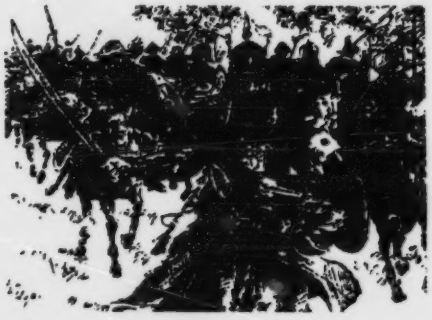
1000 A.D.



Mongols used "**gas bombs**" made of sulfur, nitre, oil, aconite, powdered charcoal, wax and resin. Bombs weighed about 5 pounds each.

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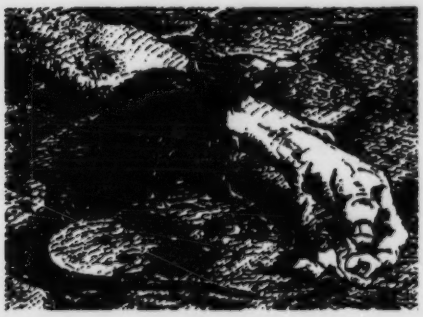
1155 A.D.

Emperor Frederick Barbarossa captured the Italian town of Tortuna after **poisoning the water supply** with decaying bodies.

DRES

1348 A.D.



Tartars at the siege of Kaffa hurled the bodies of plague victims over the city walls. **Plague broke out** in the city and the siege was broken.

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1763 A.D.

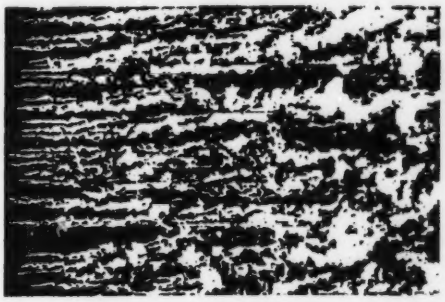
Sir Jeffrey Amherst made gifts of blankets taken from smallpox cases to natives in the Ohio Valley causing a **smallpox outbreak** amongst the natives.

World War I
Modern Chemical Warfare Begins

Modern Chemical Warfare Begins
Ypres - April 22, 1915

Along a 4 mile front, German soldiers opened the valves of 1,600 large and 4,130 small cylinders containing 168 tons of chlorine. The gas formed a thick white cloud that crossed the first allied trenches in less than a minute.

WWI - Early Chlorine Attacks

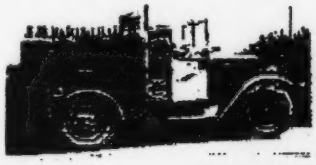


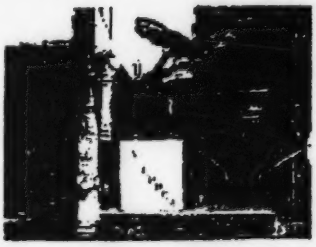
Gas rolls along the ground and flows into any depression.

Cylinders "dug in"

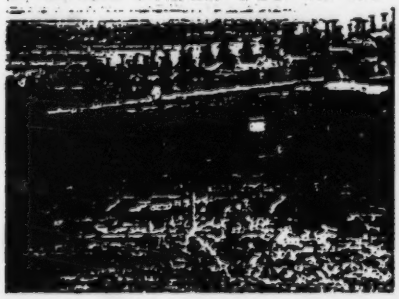
Later Chlorine Attacks

in lorries



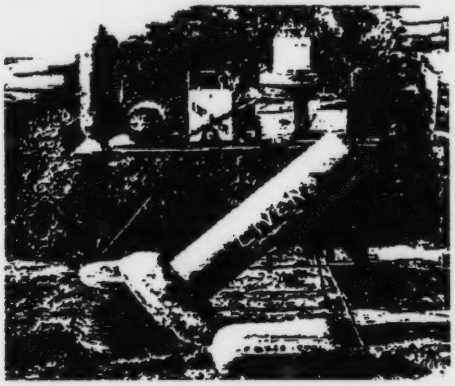


in rail cars



Cylinders opened simultaneously to provide a continuous, cone-shaped beam of gas which could penetrate over a narrow front deep into enemy territory.

Early Chemical Munitions



Livens Projector

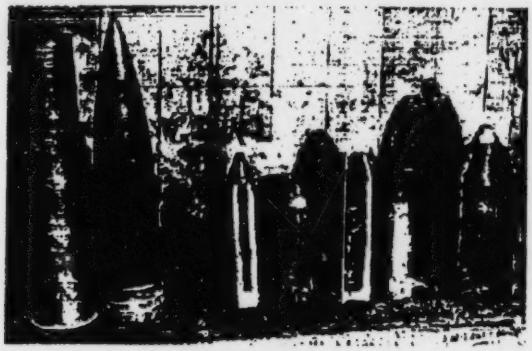
Livens Projectile
cross sectional view; central tube contains explosive charge, detonated by contact fuze; ~30 lbs of agent

Stokes Mortar

in action

mortar, ammunition and accessories for firing

WWI Chemical Munitions



principal agents: chlorine, phosgene, mustard.

Gas Casualties in WWI

blinded by Gas

killed by Gas

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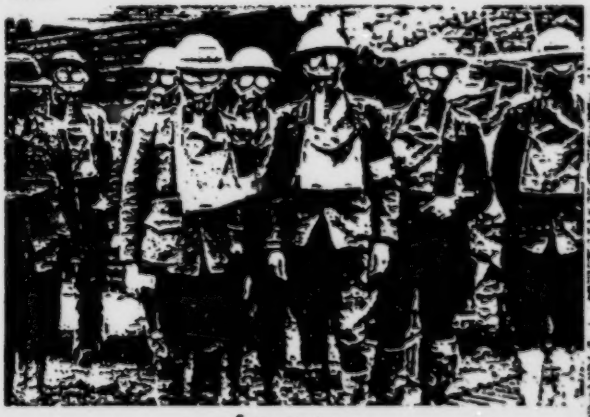
Respiratory Protection Is Essential

WWI German Masks

DRES

Respiratory Protection Is Essential

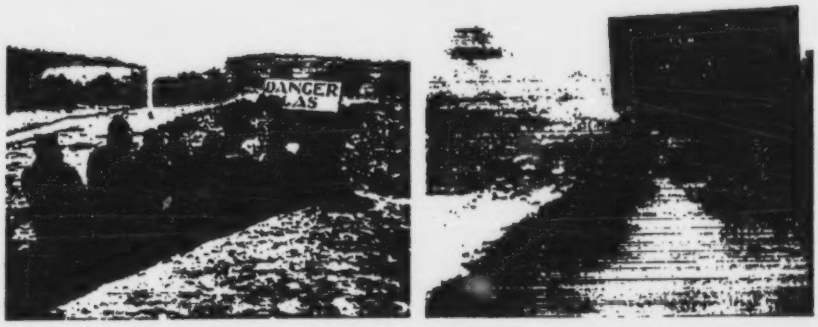


for man

British WWI Masks

and horse

Gas Training Is Essential



WWI Gas Use

- Wounded by gas - over 1.3 million
- Killed by Gas - over 91,000
- Chemicals released - 113,000 tons
- Gas shells fired - 66 million

under attack

DRES

Dr. Fritz Haber

1868-1934

"Father of Modern Chemical Warfare"

"In no future war will the military be able to ignore poison gas. It is a higher form of killing."

From Dr. Haber's Nobel Prize Acceptance Speech in 1919

DRES

Because both sides achieved comparable capabilities, especially with respect to training and protection, neit[illegible] side in World War I gained a significant advantage by using chemical weapons.

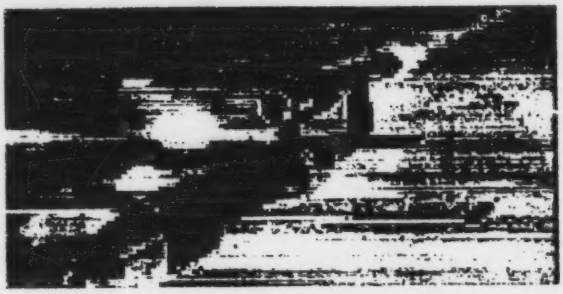
Chemical Weapons Use 1919-1939

- 1919 Russian civil war
- 1925 France, Spain against Morocco
- 1935 Italy against Abyssinia (Ethiopia)
  - 700 tons of mustard delivered by bombs and aerial spray devices
- 1937 Japan against China
  - chemical shells, tear gas grenades, lacrimatory candles often mixed with smoke
  - by 1939 escalated to mustard and lewisite

Nazi Chemical Munitions

Nazi Germany developed a variety of ways to disseminate chemical agents including artillery shells, rockets, anti-personnel devices, mines, bullets, grenades, spray tanks and aircraft bombs.

V-1 Flying Bomb

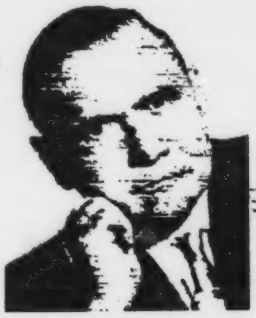


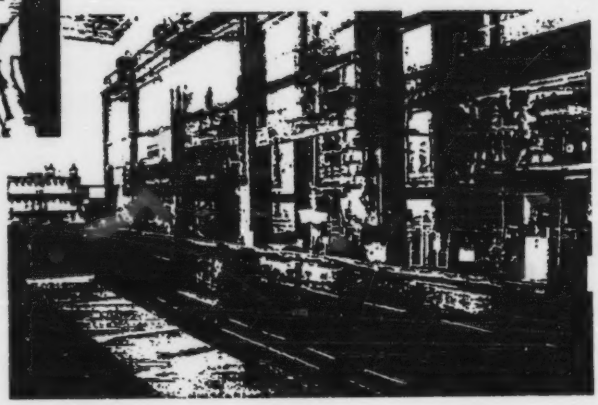
Successfully tested; capable of carrying chemical agents to London.

Gerhard Schrader

1903-1990

"Father of Nerve Agents"





Schrader's laboratory

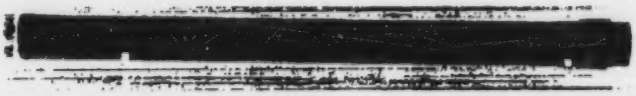
1936 - GA
1938 - GB

Nazi Chemical Production

- Approximately 78,000 tons of chemical agent produced
  - Nerve agents
    - tabun: 12,000 tons sarin: ~1,000 pounds
    - 105 mm and 150 mm shells, 250 kg bombs, 150 mm rockets
  - Mustard
    - most important agent in terms of production
    - artillery shells, bombs, rockets, spray tanks
  - Phosgene
    - 250 and 500 kg bombs
  - Nitrogen Mustard (HN-3)
    - 2,000 tons in artillery shells and rockets

Allied N-bomb Development

- When
  - in retaliation for Nazi attack against the U.K.
- Munition



  - small 4 lb bomblet, type "F" as a submunition in a 500 lb cluster bomb containing 106 bomblets
  - anthrax spores as fill
- Plan
  - 2,700 heavy bombers required to carry 40,000 of the 500 lb cluster bombs
  - simultaneous release over 6 German cities
  - estimated death toll 3 million

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Allied N-bomb Targets

UK developed anthrax, agent N, as a biological weapon. Estimated death toll from simultaneous attack against 6 cities was 3 million.

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WWII - Mickey Mouse Mask

Dozens of new and more effective gas masks were developed for everyone from newborn infants to cavalry officers and their horses.

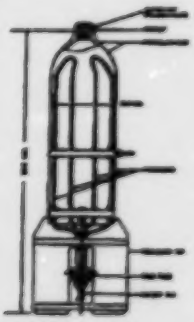
Although the Nazis had excellent chemical weapons capability, they did not use chemical weapons against the Allies as they assumed that the Allies would retaliate in kind.

Japanese Biological Warfare Program: Units 731 and 100

General Shiro Ishii

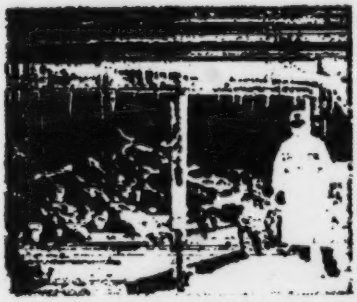
Unit 731 - to prepare for biological warfare

Unit 100 - to ready bacterial weapons for use



Old type Uji porcelain bomb

Japanese Biological Warfare Program



At least 3,000 POWs are alleged to have been used as guinea pigs in experiments with agents causing anthrax, botulism, brucellosis, cholera, dysentery, gas gangrene, meningococcal infections and plague.

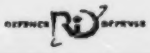
No prisoner left
Unit 731 alive

Iran-Iraq War 1980-1988

- Iraq used chemical weapons against unprepared Iranian forces
  - Mustard
    - light-case 250 lb bombs, dropped from 200-300 ft by ground attack aircraft, 8 per aircraft
  - Tabun (GA)
    - light-case 250 lb bombs
  - Other Chemicals
    - chlorine
    - arsenicals
    - nitrogen mustard
  - Anthrax (?)

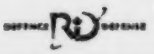
Iranian mustard casualty

Iraqi use of chemical weapons against Iranian forces, untrained and poorly equipped for chemical warfare, cancelled out the Iranian superiority in conventional weapons and manpower and allowed Iraq to obtain a truce.



Iraqi Attacks on Civilians - 1988

- Halabja
  - town had just been occupied by Iranian forces
  - bombing of the city and roads leading out of Halabja began on 16 March and lasted 2 days
  - an estimated 5,000 Kurdish civilians and Iranian soldiers killed; another 10,000 injured
  - mustard and nerve agent used
  - long term effects on survivors; respiratory, eye and skin problems, severe depression, increased suicides, range of cancers, infertility and miscarriages
- Other Kurdish villages in northern Iraq
  - 25 August
  - bombing runs by low flying jets
  - mustard and sarin used



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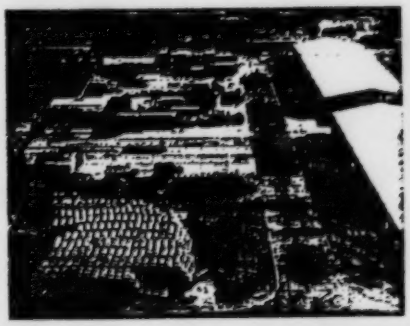
Persian Gulf War
Iraqi Chemical Weapons Program

- Chemical agents produced:
  - mustard 500-600 tonnes
  - G agents (sarin, tabun) 100-150 tonnes
  - VX 50-100 tonnes
- Chemical munitions:
  - aerial bombs
  - aerial spray devices
  - 122 mm rockets
  - 120 mm rockets
  - Scud B ballistic missiles



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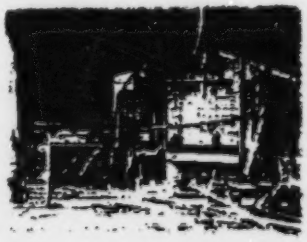
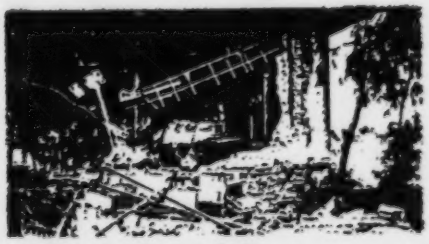
Persian Gulf War
Iraqi Biological Weapons Program

- Biological agents produced:
  - anthrax 8,400 litres
  - botulinum toxin 19,000 litres
  - clostridium (gas gangrene) 3,400 litres
  - aflatoxin 2,200 litres
  - ricin 10 litres





Laboratory building at Salman Pak

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Persian Gulf War

Iraqi Biological Weapons Program

- Biological munitions:
  - Scud missile warheads (Al-Hussein) 25
  - aerial bombs 157
  - aerial dispensers 4
- Other munitions tested for biological weapons:
  - 155 mm artillery shells
  - artillery rockets
  - MiG-21 drone
  - aerosol generators

500 lb aircraft bombs

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Although Iraq had a large chemical and biological arsenal, it did not use chemical and biological weapons against coalition forces as it perceived little advantage in so doing. Coalition forces were well trained and equipped for chemical and biological warfare.

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Conclusions

- Chemical and biological agents have been used in war.
- Chemical and biological agents will continue to be used as long as there is a perceived advantage in so doing!!!!

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Well trained and well equipped First Responders are the most effective defence against chemical and biological terrorism !!!

Section 4:

Chemical Warfare Agents, Industrical Chemicals and Toxins

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Definitions

- CW: chemical warfare
- concentration: quantity of agent vapor per unit volume (mg/m^3)
- volatility: weight of vapor present in a unit volume of air, under equilibrium conditions, at a specified temperature (mg/m^3)
- toxicity: measure of the inherent poisonous effect of a chemical agent
- dose: amount given per kilogram body weight
  - LD_{50}: amount that kills 50% of population (mg/kg)
- exposure: product of the agent vapor concentration and exposure time ($mg.min/m^3$)
  - LCt_{50}: exposure that kills 50% of population ($mg.min/m^3$)

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The Chemical and Biological Threat Spectrum

[illegible]	Emerging Chemical Warfare Agents	Bioregulators and Designer Drugs	Toxins	Genetically Manipulated Organisms	Traditional Biological Agents
[illegible]	industrial and agricultural chemicals pharmaceuticals penetrants...	peptides	bacterial, marine and plant toxins	[illegible]	bacteria rickettsia viruses

Chemical Warfare Agents

- toxic chemicals which cause death or injury to humans
  - nerve agents (e.g., sarin, soman, VX)
  - blister agents or vesicants (e.g., mustard)
  - blood agents (e.g., hydrogen cyanide)
  - choking agents (e.g., phosgene, chlorine)
  - incapacitating agents (e.g., BZ)
- primarily inhalation hazards
- secondary percutaneous hazards
- act within minutes to hours

Choking or Lung Damaging Agents

commodity industrial chemicals used in World War One

- chlorine
- phosgene - CG

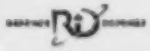
also

- PFIB
- oxides of nitrogen
- HC smokes

chlorine casualties 1915

Phosgene

- colorless gas; boiling point 8.2°C
- extremely volatile and non-persistent agent
  - heavy gas; may remain for long periods in trenches
- inhalation hazard
- causes massive pulmonary edema
  - delayed onset from 20 minutes to 72 hours depending on intensity of exposure
  - in most fatal cases, reaches a maximum in 12 hours followed by death in 24-48 hours
- supportive treatment only
  - in non-fatal cases, resolution commences within 48 hours



Choking Agents: Comparative Data

	chlorine	phosgene	perfluoroisobutylene
symbol	Cl_2	CG	PFIB
boiling point (°C)	-34	8.2	6.5
freezing point (°C)	-101	-128	
LCt_{50} (mg.min/m³) inhal. (15 L/min; 10 min)	26,000	850	5,600
ICt_{50} (mg.min/m³) inhal.	3,500		

Blood Agents

industrial chemicals

- hydrogen cyanide -CG
- cyanogen chloride - CK

Hydrogen Cyanide

- gas or liquid; boiling point 25.6°C
- primary inhalation hazard, secondary percutaneous hazard
- acts by combining with the enzyme *cytochrome oxidase* and blocking the electron transport system, resulting in impairment of cellular oxygen use
- respiratory failure is the usual cause of death
  - in high concentrations, a few breaths may cause death
- supportive therapy can effect the recovery of most casualties
- specific antidotal therapy
  - sodium nitrate and sodium thiosulfate (IV)

Blood Agents: Comparative Data

	hydrogen cyanide	cyanogen chloride
symbol	AC	CK
boiling point (°C)	25.6	13.8
freezing point (°C)	-13.4	-6
volatility (mg/m³)	1.1 x 10^6 (25°C)	2.62 x 10^6 (12.8°C)
LCt_{50} (mg.min/m³) inhal.	1000 (1 min)	11,000 (2 min)
ICt_{50} (mg.min/m³) inhal.		7,000 (2 min)

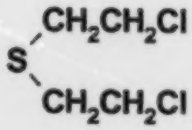
Blister or Vesicant Agents

purpose designed chemical warfare agents

- sulfur mustard
- lewisite
- nitrogen mustards

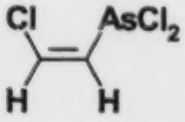
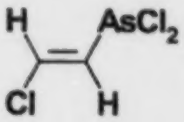
blister agent at work

Sulfur Mustard



- percutaneous and inhalation hazard
- signs and symptoms delayed 2-24 hours
- **poisonous liquid,** normally amber to black color with garlic or horseradish odor
- freezing point: 14.5°C
- low vapor pressure: 0.11 mm Hg (25°C)
- persistent agent
- used in World War I, Ethiopia prior to WWII, Iran-Iraq War, against civilians in northern Iraq

Lewisite

mixture of  and 

- percutaneous and inhalation hazard
- effects similar to mustard but more immediate and painful
- **poisonous liquid** with geranium odor
- freezing point: -1.2°C
- low vapor pressure: 0.35 mm Hg (25°C)
- non-persistent agent
- often mixed with sulfur mustard

Vesicants: Comparative Data

	mustard	lewisite	phosgene oxime	nitrogen mustard
symbol	HD	L	CX	HN-3
freezing point (°C)	14.5	-1.2	35-40	-3.7
boiling point (°C)	217.5	196	128	257
volatility (mg/m³ @25°C)	9.1×10^2	3.9×10^3		1.2×10^2
LCt_{50} (mg.min/m³) inhal. (15 L/min; 2-10 min)	900	1,200	3,200	1,500
LD_{50} (mg/man) skin	1,400	2,100		

Signs and Symptoms Mustard Exposure

- Early
  - redness, inflammation, pain
  - tearing, irritation of mucosal membranes coughing, sneezing
- Later
  - skin blisters
  - skin necrosis
- inhalation can lead to pulmonary edema and severe lung damage which results in death
- mustard symptoms depend on the site of exposure

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Skin Exposure to Mustard

- latent period of 4 - 72 hours
- pruritus, burning and erythema, pain, delayed vesiculation and edema.
- **if severe** :secondary infection and systemic manifestations such as nausea, vomiting, pyrexia, confusion and shock.

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Skin Exposure to Mustard

Iranian casualties five days after exposure to mustard

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Eye Exposure to Mustard

- Vapor
  - latent period of 4 - 12 hours
  - blepharospasm, lacrimation, pain, conjunctivitis, photophobia and eyelid edema.
- Liquid
  - blepharospasm, lacrimation, photophobia, eyelid edema, conjunctivitis and pain.

eye injury of lesser severity 7 days after exposure; edema of eyelid and conjunctivitis

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Respiratory Exposure to Mustard

- nasal irritation, hoarseness, cough, sore throat, pharyngitis, bronchitis, cyanosis, purulent sputum, bronchopneumonia and resultant leukopenia

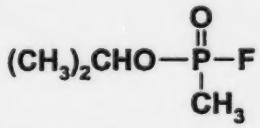
surgically excised lung from a Iranian mustard casualty showing bronchietasis and severe chronic infection

reprinted from: Freitag L, Firusian N, Stamatis G, Greschuchna D., "The role of bronchoscopy in pulmonary complications due to mustard gas inhalation", *Chest* 1991; 100:1438

Nerve Agents

- purpose designed chemical warfare agents
- organophosphorus compounds
  - tabun (GA)
  - sarin (GB)
  - soman (GD)
  - GF
  - VX

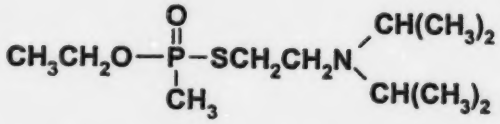
Sarin (GB)



- lethal cholinesterase inhibitor
- LCt_{50} of 35 mg.min/m^3 in man (15 L/min; 2-10 min)
- inhalation and percutaneous hazard
- colorless, odorless, **poisonous liquid**
- modest vapor pressure: 2.9 mm Hg (25°C)
- non-persistent agent
- released by AUM at Matsumoto and in the Tokyo subway

2810

VX



- lethal cholinesterase inhibitor
- most toxic chemical warfare agent:
  - LCt_{50} of 15 mg.min/m³ in man (15 L/min; 2-10 min)
- percutaneous and inhalation hazard
- colorless, odorless, **poisonous liquid**
- very low vapor pressure: 0.00062 mm Hg (25°C)
- persistent agent

Nerve Agents: Comparative Data

	tabun	sarin	soman		
symbol	**GA**	**GB**	**GD**	**GF**	**VX**
boiling point (°C)	248	158	198	239	298
volatility (mg/m³; 25°C)	4.9×10^2	2.2×10^4	3.9×10^3	6.8×10^2	8.9
persistency in soil	days	hours	persistent	persistent	days
LCt_{50} (mg.min/m³) inhal (15 L/min; 2-10 min)	70	35	35	35	15
LD_{50} (mg/man) skin	1,500	1,700	350	350	5

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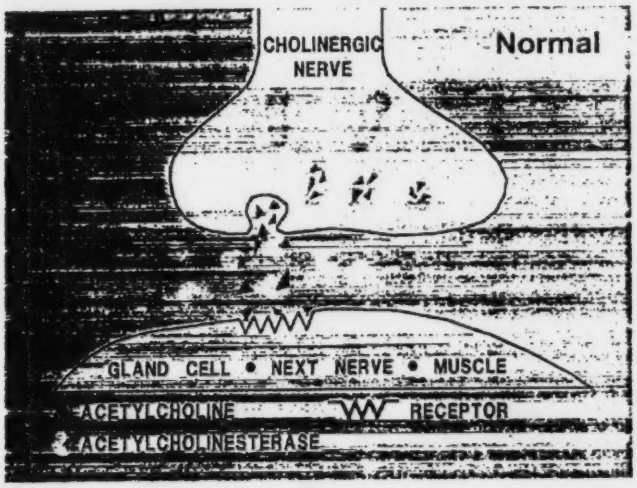
Mechanism of Action: Nerve Agent Intoxication



DEFENCE R&D DÉFENSE

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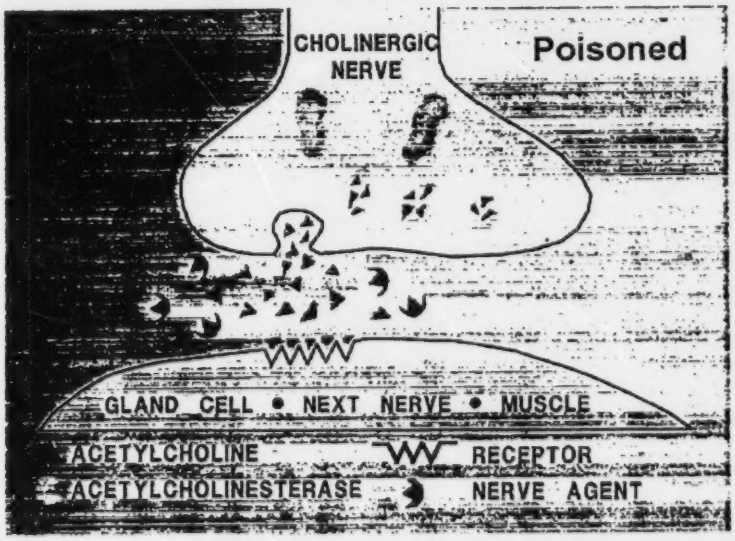
Mechanism of Action: Nerve Agent Intoxication



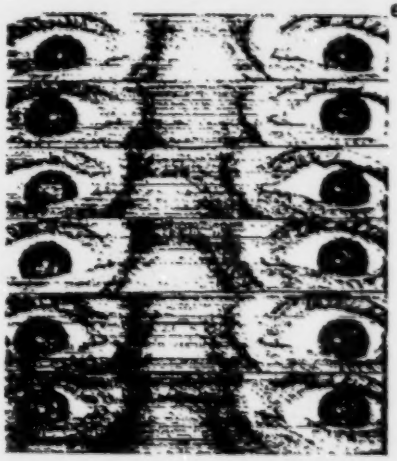
DEFENCE R&D DÉFENSE

Signs and Symptoms of Nerve Agent Intoxication

- develop rapidly after exposure (<1 to 60 min)
- symptoms in order of severity; indicative of exposure level
  - constricted pupils and dim vision
  - runing nose, excessive salivation
  - feeling of tightness in the chest
  - muscular weakness
  - intestinal cramps and diarrhoea
  - difficulty in breathing
  - convulsions

Effect of Exposure to Nerve Agent Vapor

eyes gradually recovering their ability to dilate



On-site Consequence Management for Nerve Agent Exposures

- **First Responders must have respiratory protection and avoid all liquid contamination**
  - use gloves, boots and, if possible, vapor protective suits or aprons
  - change gloves frequently
- remove obviously alive casualties from contaminated area
- do not transfer contaminated casualties to medical facility; secondary contamination must be avoided
  - decontaminate casualties prior to dispatch
    - remove all clothing; double bag; discard outside contained areas to avoid further vapor hazard

Medical Management for Nerve Agent Intoxication

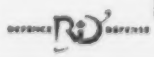
- decontaminate casualty!!!!
  - decontaminate with hypochlorite solution (household bleach diluted 1:10 with water)
  - followed by liberal wash with soap and water
- apply basic principals of emergency medical treatment:
  - secure and manage patient's airways
  - suction the airway and administer oxygen
  - start IV lines

Specific Medical Treatment for Nerve Agent Intoxication

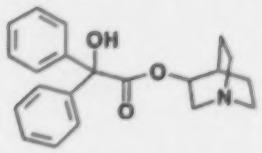
- management of moderate to severe intoxication:
  - Atropine: 2 to 3 mg administered IM or IV q 3-10 min for cholinergic symptoms
  - Pralidoxime (PAM-2) 1-2 gm IV and/or IM bolus infusion at 0.5 g/hr, monitor AChE levels
  - Diazepam 5-10 mg for convulsions
  - cardio-respiratory monitoring and ventilatory support
  - cardiac arrhythmia, etc., as a function of patient's general condition

Incapacitating Agents

- chemicals that produce temporary and non-lethal impairment of performance and perception by virtue of its psychobehavioral or CNS effects
- anticholinergic compounds
- incapacitants considered by the military include BZ (3-quinuclidinyl benzilate) and related glycolates
- considerable counterculture interest especially in anticholinergic hallucinogenic compounds present in plants
- primarily inhalation hazard
- secondary ingestion hazard (as food/water contaminants), injection hazard, percutaneous hazard



BZ: 3-quinuclidinyl benzilate



- odorless, non-irritating white solid
- inhalation hazard
  - normally disseminated as a smoke
- stable, persistent in soil and water
- BZ salts are soluble in water - suitable for contaminating water, foodstuffs
- clinical effects are delayed
  - delay depends on exposure (2 hr, range 0.5-4 hrs, at ICt_{50})
- relatively easily synthesized

BZ- Clinical Signs

- combination of anticholinergic PNS effects with the CNS effects of slurred speech, automatic behavior and realistic, describable hallucinations in a patient slipping into and out of delirium
- clinical course of BZ poisoning:
  - onset (0 to 4 hours after exposure)
    - parasympathetic blockade and mild CNS effects
  - second phase (4 to 20 hours after exposure)
    - stupor with ataxia and hyperthermia
  - third phase (20 to 96 hours after exposure)
    - full blown delirium which may fluctuate moment to moment
  - fourth phase (resolution)
    - paranoia, deep sleep, reawakening, crawling or climbing automatisms and eventual re-orientation

Comparative Lethality of Toxins and Chemical Agents in Mice**

Agent	LD_{50}(µg/kg)*	Molecular Weight	Source
Botulinum Toxin	0.001	150,000	Bacterium
Tetanus Toxin	0.002	150,000	Bacterium
Abrin	0.04	65,000	Plant (rosary pea)
Palytoxin	0.15	2,700	Marine soft coral
Textilotoxin	0.60	80,000	Elapid snake
Batrachotoxin	2.0	539	Arrow-poison frog
Ricin	3.0	64,000	Plant (castor bean)
α-Conotoxin	5.0	1,500	Cone snail
Tetrodotoxin	8.0	319	Puffer fish
Saxitoxin	10.0	299	Marine dinoflagellate
VX	15.0	267	Chemical agent
Sarin (GB)	100.0	140	Chemical agent
Aconitine	100.0	647	Plant (monkshood)
T-2 toxin	1,210.0	466	Fungal mycotoxin

* route or administration intravenous or intraperitoneal

** Medical Aspects of Chemical and Biological Warfare, Sidell, Takafuji, Franz, ed., 1997

Botulinum Toxin

- produced by bacteria, *Clostridium botulinum*
- most acutely toxic material known
- inhalation, ingestion, injection hazard
- onset time:
  - ingestion: 12 to 72 hours
  - inhalation: hours to days
- case fatality rate: ingestion - 9% with respiratory support, 70% with minimum care
- toxin readily inactivated by heat, the spores produced by *C. botulinum* are resistant
- detoxified by chlorinating water (100-300 mg/L active chlorine)
- widely distributed in the environment (e.g., soils, marine sediments)
- relatively easily produced

Botulinum Toxin - Treatment

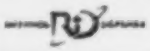
- physiological effects: ingestion - dry mouth, visual difficulty, nausea, difficulty in speech and swallowing, weakness, vomiting, dizziness, progressive paralysis and respiratory failure with severe intoxication
- duration of incapacitation: 2-6 months
- there is no specific antidote
- survival depends on immediately available intensive care and ventilatory support
- existing pentavalent vaccine is experimental

RICINUS COMMINUS

castor bean plant; leaves, seed pods and beans

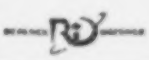
Ricin

- from beans of castor plant, *Ricinis communis*
- very easily produced, www available recipe!
- worldwide availability as by-product of castor oil production
- off-white powder
- inhalation, ingestion or injection hazard
- ingestion of 10-20 beans can be lethal
- efficacy of treatment depends on route of exposure
- used in the assassination of the Bulgarian dissident, Georgi Markov



Ricin - Treatment

- signs and symptoms: weakness, fever, cough and pulmonary edema occur 18-24 hours after inhalation exposure, followed by severe respiratory distress and death from hypoxemia in 36-72hours
- treatment is supportive:
  - treatment for pulmonary edema and hypoxemia
  - gastric decontamination measures if ingested
- efficacy of treatment depends on route of exposure
- currently no vaccine or prophylactic antitoxin available for human use
  - promising immunization studies in animal models



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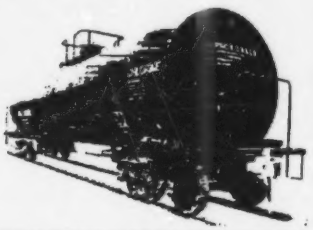
Toxic Industrial Chemicals

- toxic chemicals with legitimate industrial use
- gases, liquids or solids
- inhalation, ingestion, percutaneous or injection hazards
- rapid acting to delayed effects
- wide range of toxicities
- some have been used as chemical warfare agents
- readily accessible



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Toxic Industrial Chemical Use in World War I

- until the introduction of mustard, all chemical warfare agents were toxic industrial chemicals
- attacks were by cylinder, shell or projectile
- industrial chemicals used included:
  - chlorine
  - phosgene
  - hydrogen cyanide
  - chloropicrin

Major Industrial Accidents

If the Bhopal methyl isocyanate incident is excluded, analysis of major industrial accident data shows that:

- majority of fatalities occurred within 400 m of the release
- the greatest hazard is from the release of pressurized liquified gases
- principal chemicals of concern:
  - chlorine
  - ammonia
  - hydrogen sulfide

Chemical Production in Canada*

Chemical	Quantity (tonnes)	Chemical	Quantity (tonnes)
ammonia	**4,779,000**	benzene	715,000
sulfuric acid	**4,100,000**	polyvinyl chloride	539,000
urea	3,470,000	xylenes	362,000
ethylene	3,272,000	toluene	321,000
polyethylene, LD	1,397,000	**formaldehyde**	**210,000**
sodium hydroxide	1,081,000	polystyrene	181,000
chlorine	**1,045,000**	aluminum sulfate	162,000
sodium chlorate	1,038,000	butadiene	221,000
nitric acid	**1,008,000**	carbon black	205,000
ammonium nitrate	980,000	hydrogen peroxide	179,000
propylene	860,000	**hydrochloric acid**	**141,000**
polyethylene, HD	793,000	polyesters, unsaturated	71,000

*1997 figures from *C&E News*, June 29, 1998, pp 72-3.

Industrial Chemicals of Particular Concern

- commodity toxic gases (chlorine, ammonia, hydrogen cyanide, phosgene)
- organophosphorus and carbamate insecticides
  - solids or low volatility liquids
  - used on a large scale in agriculture (16,100,000 lbs used in California in 1997
  - same mechanism of action as nerve agents
  - some have toxicities approaching G-agents
    - rat LD_{50}s (µg/kg)
      - aldicarb 500 oral, 470 iv
      - GB 550 oral, 39 iv
- cyanides

Conclusions

- terrorists have launched chemical attacks
- **First Responders must consider their own protection, control the impact zone and ensure decontamination of those leaving it.**
- timeliness of response is critical
- most casualties will not be fatalities!!!
- expect medical resources to be quickly depleted

Conclusions

- coordination of government (3 levels), medical, scientific, forensic resources essential
- practice exercises essential to early control, diagnosis, treatment, prophylaxis
- prophylaxis and treatment resources must be identified and positioned for instant deployment

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DEFENCE R&D DÉFENSE

Section 5:

AUM Shinrikyo; Chemical and Biological Terrorism

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DEFENCE R&D DÉFENSE

AUM SHINRIKYO

Chemical and Biological Terrorism

Canada

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AUM SHINRIKYO (Supreme Truth)

"After eight years of strenuous practice of Yoga and Buddhism, **His Holiness the master, Shoko Asahara** attained final enlightenment in the Himalayas in 1986. He founded AUM Shinrikyo in 1987 and continues to develop himself to the severe practice of Mahayana path."

"In this age of crisis, his unique leadership with altruism and devotion has great significance to world peace and the survival of human beings."

from AUM website
(www.aum-shinrikyo.com/english/master.htm)

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AUM SHINRIKYO (Supreme Truth)

- "new religion" founded by Shoko Asahara in 1987
  - granted official "religious corporation status" in August 1989
  - amalgam of Buddhist and Hindu theology around the practice of yoga
  - enlightenment and superhuman feats achieved by following AUM teaching
  - psychological manipulation, brainwashing, coercion practiced
  - by 1994, 10,000 adherents in Japan, 10,000-40,000 in Russia
    - 30 branches in 6 counties
  - heavy recruiting in universities and among wealthy
  - more that $1 billion in assets
  - operated legitimate businesses, including private hospitals
  - successfully infiltrated Japanese government and industry

AUM SHINRIKYO

- predicted imminent apocalypse in 1997, 1999 or 2000
  - Armageddon arrives in a gas cloud from the U.S.
  - enlightened followers of AUM and 10% of others would survive
  - AUM would arise as the supreme power in Japan
- perpetuated several chemical and biological attacks:
  - **27 June 1994: Matsumoto Incident - sarin**
  - December 1994-January 1995: assassinations - VX
  - 15 March 1995: Tokyo rail station - botulinum toxin
  - **20 March 1995: Tokyo Subway Attack - sarin**
  - May-July 1995: Tokyo subway station - hydrogen cyanide

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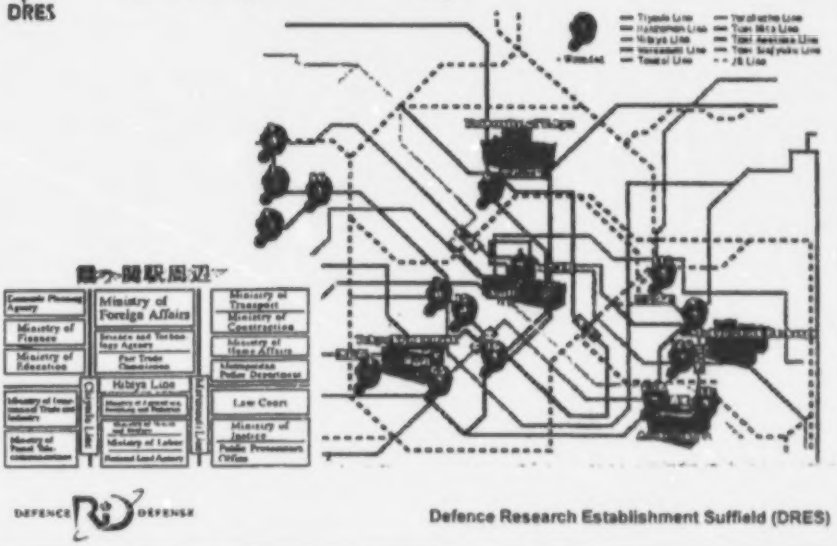
Subways in Tokyo



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Scale of Attack

Five million commuters use the Tokyo subway system at rush hours.

Placement of Devices

08:05 Hibiya Line, Nakamegura-bound, third car Tsukiji Station - report of an "explosive"

08:08 Chiyoda Line, Yoyogi-uehard bound, first car, Kasumigaseki Station

08:13 Hibaya Line, Tobu-bound, first car, Kasumigaseki Station

08:26 Maronouchi Line, Ogibuko-bound, third car, Nakano-sakaue Station

08:46 Maronouchi Line, Shinjuku-bound, second car, Hong Sanchome Station

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Sarin in the Tokyo Subway

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Scale of Attack

Device Description

- 11 packages were placed in 5 cars on 3 lines
  - plastic bags (resembling transfusion bags) approximately 20 cm^2 with heat sealed edges
  - some bags were wrapped in newspaper
- 6 liters of impure sarin used
- bags were pierced with the tip of an umbrella allowing the contents to seep out

Initial Chronology of Emergency Response

08:05-08:46	attacks reported on subway system
08:20	first call to police and fire department
08:26	police and ambulance respond
08:40	first casualties arrive at St. Luke's Hospital
08:42	Metropolitan Police Department (MPD) set up countermeasures HQ
09:00	National Police Agency set up countermeasures HQ
10:20	sarin reported as causative agent by Japanese Self Defence Forces (JSDF) and MPD laboratory
12:50	JSDF begin operations mainly in decontamination support

Tokyo Subway Attack - 20 March 1995

Casualties

- total 5510
  12 dead, 13 critical, 37 severe, 984 moderate, 4464 mild
- initial casualties most severe
- several deaths amongst those who handled or were near the packages, especially amongst subway personnel
- immediate action by subway personnel helped reduce casualties (moving to other cars, etc)
- several people more affected because of attempts to support/help victims
- 160 police and 135 fire department personnel secondary casualties

Factors which Complicated the Initial Response

- initial reports of a bomb gave first responders an incorrect appreciation of the threat
- on-site Hazmat analysis gave indications of acetonitrile, isopropyl alcohol and diethylaniline which were solvents or starting materials in the procedure used to produce sarin and not the cause of the primary symptoms
- poor respiratory protection and contamination control
  - chemical identification personnel went in unprotected and suffered sarin poisoning

General Symptoms of Presenting Patients

Mild Cases:

Eye:	miosis, ophpthalmalgia, cloudy vision, dark vision, conjunctiva congestion
Nose:	pituita
Respiratory Organs:	dyspnea, cough, chest pressure
Digestive Organs:	nausea, egestion, diarrhea
Muscles:	numbness, muscular contraction
Mental:	anxiety, headache

Serious Cases (in addition to above sins and symptoms):

respiratory arrest, fasciculation, convulsion, clouding consciousness, gatism

General Symptoms of Patients Presenting at St. Luke's Hospital

Age	Sex	Symptom	Prognosis
32	F	miosis, cardiac and respiratory arrest	dead
21	F	miosis, cardiac and respiratory arrest	dead on 23rd day
27	F	miosis, cardiac and respiratory arrest	left hospital on 6th day
55	M	miosis, clouding consciousness, respiratory arrest	left hospital on 3rd day
27	M	miosis, clouding consciousness, convulsion, respiratory arrest	left hospital on 4th day

Treatment Protocol
JSDF Hospital

Nicotinic symptoms:	observation and support
Muscarinic symptoms:	Atropine: 2-6 mg q 10 min IM or IV titrated to secretions
	PAM: 1-2 g IV 30 min infusion repeated every 60-90 min as required
	Diazepam: 5-10 mg for convulsions
	ACLS

Impact on St. Luke's Emergency Resources

- 640 patients triaged in 2 hours: 90-95% ambulatory
- 110 patients admitted on day of attack
- total of 1410 patients seen in 24 hours
- 5 major hospitals handle the bulk of the first day's casualties

Japanese Self Defence Force CB Response and Countermeasures

Detection

- NAVD-type detector for nerve agents
- detector paper

Decontamination

- sodium hypochlorite (bleach)
- dilute sodium hydroxide

Hospital and Emergency Medical Response

- arrive alive = survive
- treatment protocol based on clinical assessment of patient
- rapid patient recovery
- minimal residual effects
- secondary contamination
- long term follow-up

Emergency Response Deficiencies

- on-site emergency medical treatment
- respiratory protection for first responders
- agent detection capability
- contamination control
- poor communication among organizations concerned

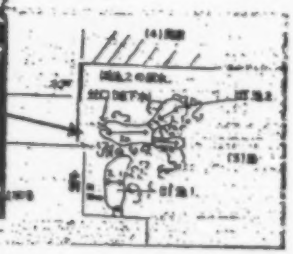
Tokyo Advantages

- Earthquake preparedness:
  - training in large casualty situations
- CW threat preparedness:
  - Matsumoto sarin incident, VX assassinations
  - stocks of Atropine and 2-PAM available
  - sarin easy to treat

Matsumoto Incident - 27 June 1994

Dry Run for Tokyo

Matsumoto
small industrial and resort city of several hundred thousand people
100 miles west of Tokyo



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Matsumoto Incident

- late in the evening of 27 June 1994
- quiet residential area of Matsumoto City
- victims asleep in rooms on second or higher floors of medium height apartment buildings
- sultry night; windows open
- 269 victims
  - seven dead (five on site; two in hospital)
  - one in vegetative state
  - 56 hospitalized; average stay of 9.8 (1-84 days)
  - 208 out patients

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Communications - Matsumoto

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- 00:30 Police to Health Center:

  "About 10 residents of Kita Fukasi 1-chome complained about biting pain in their eyes. They were carried to hospitals. Cause unknown."

- 01:00 Police to Health Center:

  "What local office is responsible for matters involving toxic gas?"

- 03:20 Police to Health Center:

  "No cause identified. Initial symptoms include headache, nausea, diarrhea. Those who died had froth at their mouths and red spots on the skin."

- 05:10 Police to Health Center:

  "Death toll reached 7. Damaged area is in an oval shape long from north to south centering to Kaichi Heights. Doctors who talked to the victims said that symptoms include darkening view in purple color, like when wearing sunglasses. They had runny noses."

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Medical Treatments - Matsumoto

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- "Doctor Car" one of the first vehicles on scene
- common symptoms of hospitalized cases:
  - miosis, nausea, egestion, headache, numbness
  - also in serious cases fasciculation, hallucinations, gatism
- six hospitals correctly diagnosed that poisoning was caused by an organophosphorus compound
- atropine sulfate administered
- PAM, DHP and thiopental sodium also administered to serious cases

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Investigation of Matsumoto Attack

- samples taken on 28 June 1995
  - air in house and garden and water in ponds near incident
    - sarin confirmed in water by mass spectrometry
- initial police investigation focused on the wrong suspect
- testimony by AUM members after the Tokyo subway attack revealed that the Matsumoto attack was:
  - an attempt to kill judges hearing a case involving AUM
  - sarin was released within 30 feet of judges' residence
    - sarin sprayed from nozzle device attached to a truck, specially outfitted for the purpose
    - electric heater used to vaporize the liquid for dispersal by a fan
  - gassing lasted ~ 10 minutes with gas carried on a southeasterly wind into the targeted residence

Canadian Perspective

- no or minimal large casualty (>5,000) emergency response training
- too few hospital beds
- insufficient quantities of CW therapeutic drugs (atropine, 2-PAM)

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Conclusion

- Severity, consequences and impact of such a terrorist attack is entirely dependent on the training, capability and resources of the local emergency response system.
- Tokyo emergency and hospital response was massive, effective and well organized.

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Biological Warfare Agents

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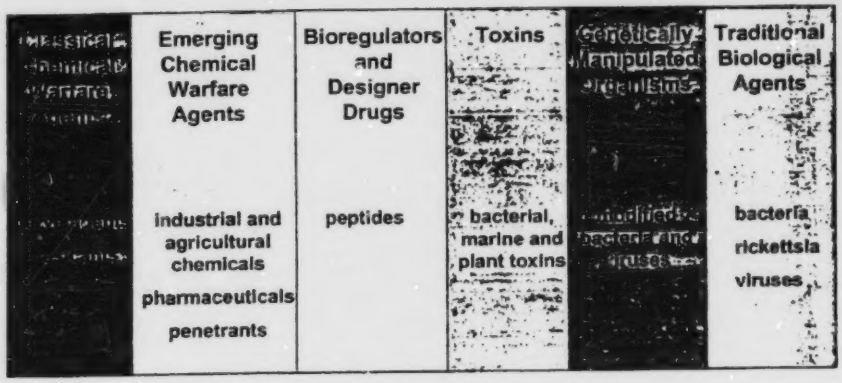
Outline

- aerosol hazard
- biological agents
  - agent characteristics
  - agent selection
  - anthrax
  - smallpox
  - plague
  - salmonella
- biological incidents
- epidemiology of a BW attack
- conclusions

The Chemical and Biological Threat Spectrum



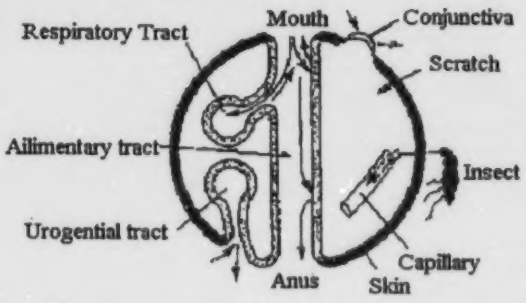
Biological Warfare (BW) Agents

- living organisms which cause death and injury to humans
  - bacteria (e.g., anthrax, plague, cholera, salmonella)
  - rickettsia (e.g., Q-fever)
  - viruses (e.g., Ebola, equine encephalitis)
- inhalation, ingestion, injection hazards
- slower acting (days)
- in some cases, one organism can initiate infection

Routes of Entry into Body

For a toxic material to be effective it must enter the body:

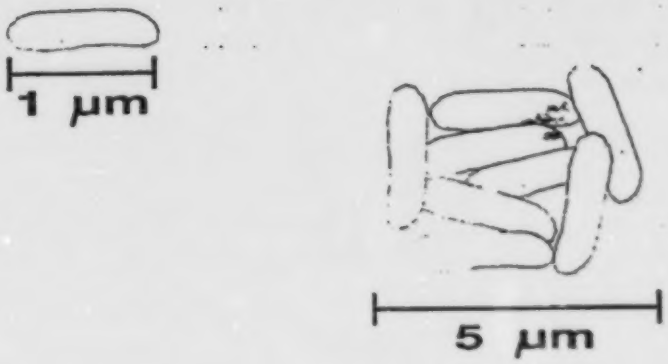
- inhalation
- through skin (percutaneous)
- ingestion
- injection



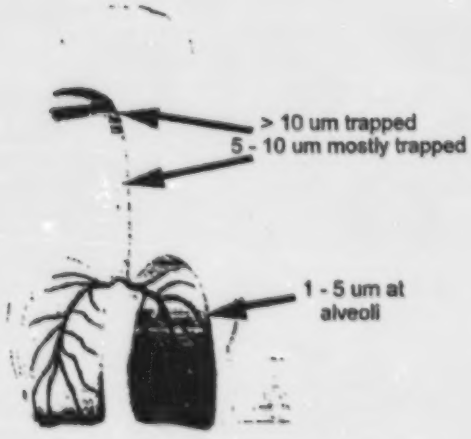
The Inhalation Route

- The infectious material must be an aerosol.
- Offensive advantages of the inhalation route:
  - the lung is a highly efficient route of entry
  - aerosols have a high penetration capability
  - aerosols are difficult to detect
  - infections are difficult to diagnose
  - pulmonary infections are more severe
  - massive overdoses are possible

Aerosol Particle Size

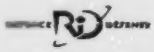


Aerosol Impaction in the Body



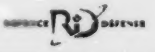
Ideal BW Agent

- no detection available
- no rapid diagnostics available
- lethal or incapacitating
- prevention difficult
- predictable incubation period
- prolonged illness
- no definitive treatment
- narrow treatment window
- prolonged treatment



Ideal BW Agent

- countermeasures costly or difficult to administer, logistically difficult to deal with
- transmissibility
- infectivity = dose response
- virulence
- ease of handling and dissemination
- availability
- ease of production
- stability in storage and as a weapon



Biological Agents in the U.S. and Russian BW Programs

Biological Agent	U.S.	Russian
Smallpox		X
Plague		X
Anthrax	X	X
Botulinum Toxins	X	X
Venezuelan Equine Encephalitis (VEE)	X	X
Tularemia	X	X
Brucella	X	
Glanders		X
SEB	X	
Q-fever	X	X
Marburg		X

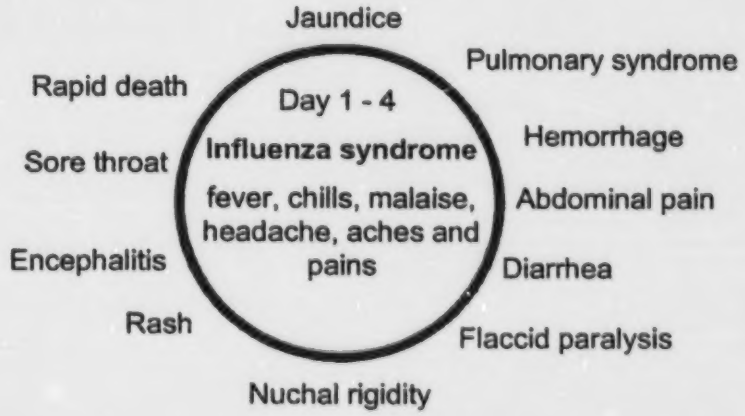
The John Hopkins Expert Panel

- an expert panel review of the open literature
- produced an unclassified medical risk analysis and threat list
  - agents which would cause maximum casualties and economic loss
- analysis and list used in U.S. biological counterterroism planning

The John Hopkins Expert Panel Medical Threat List

- Anthrax
- Smallpox
  - Plague
  - Tularemia
    - * Botulinum Toxins
    - * Equine Encephalitides (EEs)

"Real" Effects of BW Agents

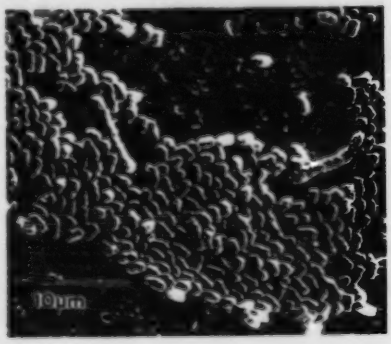


Anthrax - characteristics

- caused by bacteria, *Bacillus anthracis*
- organism exists as a spore in the soil
- anthrax occurs worldwide
  - cutaneous anthrax (95% of cases; mortality <1%)
  - inhalation anthrax (mortality essentially 100%)
  - gastrointestinal anthrax (mortality up to 50%)
- inhalation, ingestion, percutaneous hazard
- moderate infectivity (8,000 CFU); not transmissible
- incubation period of 1-5 days, illness lasts 3-5 days
- spores very resistant; can survive in soil for years
- easily produced
- diagnosis extremely difficult because of non-specific initial presentation

Anthrax - characteristics

Gram's stain of blood smear from a rhesus monkey that died of inhalational anthrax



scanning electron micrograph of a preparation of *Bacillus anthracis* spores; oval shaped spores, elongated bacteria

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Anthrax - early signs

- cutaneous - malignant pustule
- inhalation - stage one
  - malaise, fatigue, myalgia, mild fever, nonproductive cough, thoracic discomfort
- inhalation - stage two
  - short improvement followed by severe respiratory distress (dyspnea), cyanosis (blue), diaphoresis (profuse sweat), stridor (inspiratory high pitched respiration)
  - chest X-ray - widened mediastinum, pleural effusion ± (without infiltrates)
  - bacteremia, septic shock, meningitis (50%)
- diagnosis
  - blood culture (advanced stage at day 2-3), chest X-ray, T-ELISA

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Effects of Anthrax Exposure

cutaneous lesion of anthrax

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Effects of Anthrax Exposure

chest X-ray, taken on day 2 of illness, showing the lungs of a 51 year old man with occupational exposure to anthrax spores

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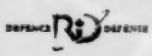
Effects of Anthrax Exposure

brain from patient exposed to inhalational anthrax

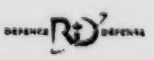
Anthrax - medical management

- immunization available
  - up to 6 doses and 18 months to develop immunity; then annual boosters
  - good protection against aerosol challenge in animals
  - mildly reactogenic 5-8%, severe <1%
- prophylaxis with antibiotics (e.g., Ciprofloxacin 500 mg bid, Doxycycline 100 mg bid)
- therapy with antibiotics for 60 days (e.g., Ciprofloxacin 400 mg q8-12h, Doxycycline 200 mg -100 mg q12h, Penicillin $2x10^6$ U q2h)
  - suppresses but doesn't cure
  - use with immunization if exposure occurs
- support airway, shock, fluid deficit



Anthrax - medical concerns

- Canadian stockpiles of anthrax vaccine
  - only limited quantities ear marked for military contingencies
  - civilian stockpiles do not exist
  - current cost = U.S. $51.20 per dose



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Sverdlovsk Anthrax Incident

- an unusual anthrax epidemic in Sverdlovsk, USSR, in April-May 1979 attributed by Soviet officials to consumption of contaminated meat
  - 96 human cases with onsets from 4 April to 18 May
- U.S. agencies attributed epidemic to inhalation of spores accidentally released at a military microbiology facility in the city
- epidemiological data showed that the majority of victims worked or lived in a narrow zone extending from a military facility to the southern city limit
  - further south livestock died of anthrax along the zone's extended axis out to 50 km
  - zone paralleled the northerly wind that prevailed shortly before the outbreak

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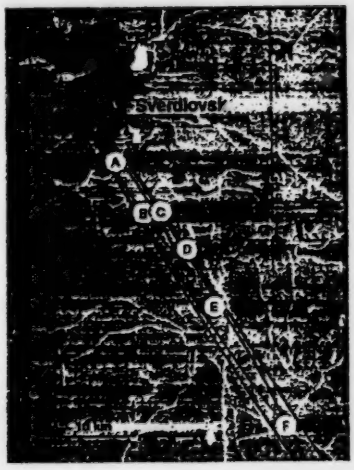
Sverdlovsk Anthrax Incident

probable location of patients



villages with animal anthrax

Sverdlovsk Anthrax Incident

- final death toll estimated between 200-1000
- in 1992 Yeltsin admitted release from military facility
- epidemiological study (Meselson, M., *et al*, *Science*, vol 266, 1202-1208, 18 Nov 1994) concluded:
  - the outbreak resulted from the windborne spread of an aerosol of anthrax pathogen
  - the source was the military microbiology facility
  - escape of the pathogen occurred during the day on 2 April
  - actual incubation periods of 2-43 days, modal 9-10, versus 1-6 days estimated from very limited human data
    - in non-human primates incubation period is inverse to dose
    - spores remained viable in lungs for many weeks
- deliberate release should be considered when:
  - large unexplained outbreaks occur
  - odd contamination patterns appear
  - poor epidemiological benchmarks

Anthrax Threats at Abortion Clinics

- clinics in Indiana, Kentucky, Tennessee, California threatened: all hoaxes
  - letter allegedly containing anthrax spores
  - phone threats of anthrax contamination in HVAC systems
- guidelines developed (MMWR, Feb 05, 1999, 48(04); 69-74; www.cdc.gov/epo/mmwr/preview/mmwrhtml/00056353.htm)
  - bag letter
  - decontaminate area with 5% hypochlorite (household bleach)
  - provide temporary shelter
  - have victims disrobe and shower with copious soap, water
  - bag/inventory personal effects
  - administer chemoprophylaxis (Ciprofloxacin 500 mg bid)
  - diagnostics: microscopy, culture, direct fluorescent antibody (DFA) (level-3 facility)

Smallpox - characteristics

- caused by *Variola major* virus
- aerosol hazard
- highly infective and highly transmissible
  - not infective until onset of disease, however, subclinical cases will be infective
- incubation period 7-17 days (average 12 days)
- duration of illness 12-48 days
- natural fatality rates quoted as 10-50% but may be much higher for selected strains
- virus is stable; survives for well over a year in crusts
- diagnosis by electron microscopy of culture, PCR

Smallpox - clinical signs

- incubation: average 12 days
- fever, myalgia, erythematous rash (10%), nausea, rigors, vomiting, delirium (15%), maculopapular rash, pustulation
- enanthem (mucous eruptions), rash face, hands, arms
- eruptions lower body
  - macular..papular..pustules…scabs 8-14 days post infection
- centrifugal distribution key to diagnosis
- lesions-synchronous development on body (vs) truncal distribution of *varicella*
  - (1) face, hands, arms (2) lower extremities (3) trunk
- infectious until all scabs cleared
- **differential diagnosis:** chickenpox, erythema multiforme, contact dermatitis
- electronmicroscopy, Guarnieri bodies, PCR
- **problem of mild cases and asymptomatic shedders**

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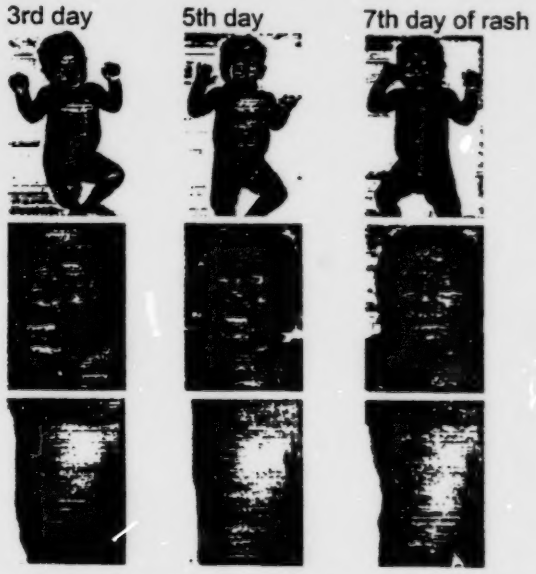
Effects of Smallpox

skin lesions in unvaccinated infant



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Smallpox - prophylaxis and treatment considerations

- **no proven treatment**
  - antiviral drugs (cidofivir, adefovir, dipivoxil, cyclic cidifovir, ribavirin) are currently being evaluated vs monkeypox
- existing licensed vaccine is highly reactogenic, can only be used if sufficient supplies of VIG are on hand
- vaccine will prevent disease if administered within 2 days of exposure
- vaccine will prevent death if given within 5 days of exposure
- no current manufacturing capability for licensed vaccine
  - with the eradication of smallpox no economic incentive to continue to manufacture this vaccine

Smallpox - prophylaxis and treatment considerations

- **entire population is vulnerable**
  - no routine vaccination for the last 20 years
  - vaccination provides solid immunity for three years after which revaccination is required
- widespread use of licensed vaccine would be complicated in a general civilian population
  - immunocompromized individuals at risk (e.g., cancer patients, transplant recipients, HIV)
  - no current source of VIG
- new vaccine (cell-culture), currently undergoing clinical trials

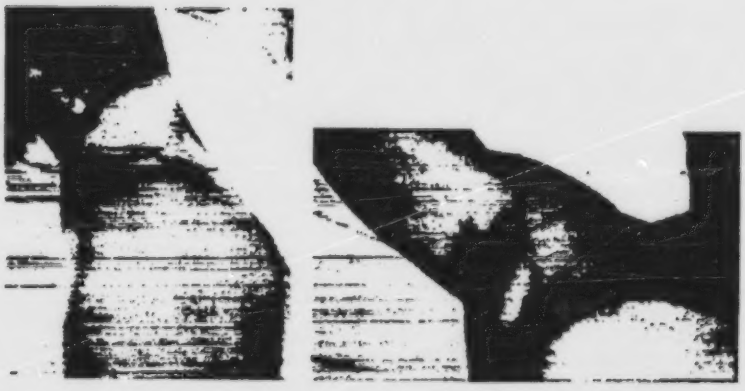
Plague - characteristics

- caused by bacteria, *Yersinia pestis*
- plague occurs in three clinical manifestations
  - bubonic (84%; mortality 60% without treatment)
  - septicemia (14%; mortality 100% without treatment)
  - pneumonic (2%; mortality 100% without treatment)
- pneumonic form
  - inhalation hazard
  - high infectivity (est. 100 CFU)
  - high transmissibility
  - incubation period of 2-3 days, illness lasts 1-2 days
- bacteria can survive 100 days in blood and up to 270 days in human bodies
- diagnosis possible in lab using microscopy, serology and PCR

Plague - clinical signs

- Bubonic plague
  - painful lymphadenopathy, fever, chills and headache
- Septicemic plague
  - fever, chills, nausea, vomiting, diarrhoea, purpura (bleeding through leaky blood vessels)
- Pneumonic plague
  - fever, dyspnea, stridor, cyanosis, shock, cough, watery bloody sputum
  - diagnostic: chest X-ray - patchy or consolidated bronchopneumonia

Bubonic Plague



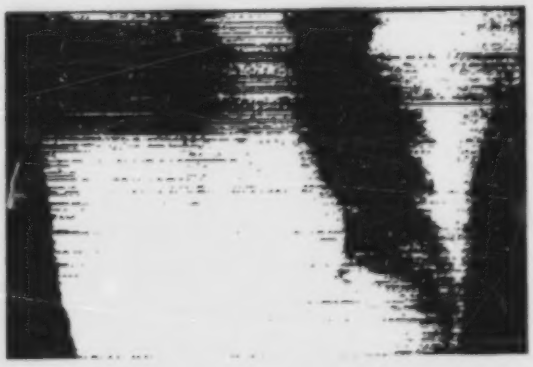
femoral bubo

bubo in cervical area

Bubonic Plague

bubonic plague that disseminated to septicemic and pneumonic forms

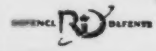
Pneumonic Plague



chest X-ray showing right middle and lower lobe involvement in a patient with pneumonic plague

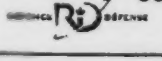
Plague - treatment and prophylaxis considerations

- Greer vaccine is no longer manufactured
- killed plague vaccine, manufactured in Australia by CSL, is not licensed in U.S. or Canada
- antibiotics (e.g., streptomycin or tetracycline) have been shown to be effective both in treatment and prevention of disease
  - drug of choice (streptomycin: 30 mg/kg/day (IM) in two divided doses for 10 days)
  - if not available, other acceptable drugs
    - gentamincin, tetracycline, chloramphenicol
    - IV doxycycline: 200 mg initial dose followed by 100 mg q12h for 10-14 days
- supportive therapy - fluids, hemodynamic monitoring
- new generation candidate vaccines currently undergoing evaluation may be effective against aerosol challenge



Oregon Salmonellosis Outbreak

- large community infection of *Salmonella Typhimurium* infections: total of 751 cases
- patients with *Salmonella* gastroenteritis associated with eating or working in area restaurants
- outbreak occurred in two waves September-October 1984
- 10 restaurant involved; salad bars identified as major risk factors
- no common link to water supply, food item, supplier or distributor identified in all affected restaurants
- employees not identified as exposed to any single common source
- errors in food rotation and inadequate refrigeration may have been contributory but could not have caused the outbreak



Oregon Salmonellosis Outbreak

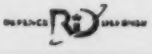
- criminal investigation revealed religious commune had deliberately contaminated salad bars
  - *S. Typhimurium* found in commune laboratory was indistinguishable from outbreak strain
- be suspicious when:
  - large/extended outbreak occurs
  - range of implicated food items
  - consistent area of infection or point source
  - no common food item, water source, supplier, distributor
  - employees not exposed to common source
  - no evidence linking employees
  - non contributing evidence to large outbreak

Epidemiology of a BW Attack

- humans are often the most sensitive, or only, indicator of a BW attack
- the most likely first indicator of a BW attack is an increased number of patients presenting with signs and symptoms caused by the disseminated agent
- documenting who is affected, possible routes of exposure, signs and symptoms of disease and the rapid identification of the causative agent will greatly increase the ability to plan an appropriate medical response
- most diseases caused by BW agents present with nonspecific signs and symptoms that could be misinterpreted as natural occurrences.

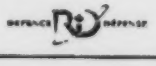
Epidemiology of a BW Attack

- disease pattern is an important factor in differentiating between a natural outbreak and a BW attack
- natural epidemics
  - **gradual rise in disease incidence** as persons are progressively exposed to an increasing number of patients, vectors or formites that spread the pathogen
- BW attack
  - all potential victims exposed to the agent at approximately the same time
  - **compressed epidemic curve with a peak in a matter of days or even hours**
- point source outbreaks require careful investigation



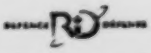
Epidemiological Assessment of a BW Attack

- formulate a case definition
  - determine actual number of cases and approximate attack rate using objective criteria
  - compare disease rate with natural background rate
- describe epidemic
  - timing
  - place
  - characteristics of those that are ill



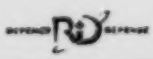
Epidemiological Assessment of a BW Attack

- indicators of BW attack
  - casualty location; is a pattern followed?
  - unusual disease presentation
  - high disease rate among exposed individuals
  - more respiratory cases
  - unusual geographical occurrence of disease
  - natural vector borne disease in an area where vector does not occur
  - superimposed epidemics
  - higher morbidity and mortality than normally expected
  - lower incidence in personnel protected from exposure (e.g., inside buildings)
  - suspicious activity or discovery of a potential delivery system (e.g., sprayer)



Minimizing the Effects of a BW Attack

- **First Responders** (especially health care professionals) must:
  - be aware of the threat of biological warfare and terrorism
  - have an increased index of suspicion that such an attack can occur (not paranoia)
  - have some understanding of the classes of agents that have been weaponized and their effects after inhalation
  - **have ongoing surveillance of background disease activity**
    - pay close attention to disease patterns
    - follow up on any unusual change in disease occurrence or ethiology



Conclusions

- **terrorists have launched biological attacks**
- biological agents are invisible, tasteless, odorless
- attack should go undetected until the first casualties present for medical care
- early cases will be misdiagnosed
- many effective agents, bacterial favored
- inhalation - route of exposure for large number (i.e., >1,000) of casualties
- food and/or beverage contamination attractive to terrorists

Conclusions

The Bad News

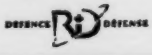
- vaccine prophylaxis is very unlikely for the general population
- vaccine prophylaxis is unlikely for First Responders:
  - vaccines do not exist for most threats
  - available vaccines are IND status only in Canada

The Good News

- antibiotic treatments are effective
- incubation periods are such that First Responders and Medical Personnel can initiate prophylactic treatment if they are alert to the "signs" and prompt with identification/diagnosis

Conclusions

- coordination of government (3 levels), medical, scientific, forensic resources essential
- practice exercises essential to early control, diagnosis, treatment, prophylaxis
- prophylaxis and treatment resources must be identified and positioned for instant deployment



Section 7:

The Attack

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DEFENCE R&D DÉFENSE

The Attack

Terrorist Groups
Possible Targets
Dissemination Devices
Sources of Agents

Canada

DRES

Outline

- general considerations
- terrorist groups
- possible targets
- dissemination devices
- agents of choice
- sources of agent
- possible scenarios
- conclusions

General Considerations

- selection of the target, dissemination device, agent and scenario will depended upon:
  - type of terrorist group
  - aim of the terrorist group
  - experience of the terrorist group
  - geographical setting of the planned event
- explosives may or may not be used

Classification of Terrorist Groups

- state-supported group
  - essentially Special Forces operations of a foreign government
  - limited by technical/logistical expertise of the sponsoring government
- domestic group
  - formed for single event
  - formed for long term
- individual with specific technical expertise
  - may be very difficult to detect
  - has expertise to design effective scenario
  - has ready access to agent, dissemination devices, protective equipment, etc.

Single-Event Domestic Terrorist Group

- ideally, has members with bachelor's degrees or technical school diplomas in health sciences, microbiology, chemistry or chemical engineering, mechanical engineering, atmospheric physics or meteorology, and computer science
- uses information available in university or public libraries or on the Internet
- cultivates and disseminates agent using readily available media and equipment (e.g., nothing special which would attract attention is used)

Long-Term Domestic Terrorist Group

- front as legitimate company engaged in:
  - agricultural spraying
  - commercial/residential pest control
  - greenhouse operations
  - medical diagnostics laboratory
  - specialty chemical production
- front provides:
  - legitimate reason for obtaining cultures, chemicals, spray equipment, protective equipment, training
  - excellent on-the-job training for "future" operations
  - legitimate source of revenue to finance operations

Minimum Requirement for a Chemical or Biological (CB) Attack

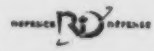
- to plan and execute a CB attack, the terrorist group would, as a minimum, need to be able to:
  - develop a credible attack scenario/concept of use
  - identify candidate agents
  - obtain sufficient agent for the attack
  - obtain a suitable delivery system
  - have a basic understanding of the effect of meteorology
  - understand the protective measures which must be employed to safely use the selected agents

Possible Targets

- Public Transportation Systems
  - essential service
  - terminals and vehicles are both vulnerable
  - moderate number of potential victims
    - number of potential victims is greater in terminal than in vehicle
  - possible to selectively target a segment of the population (e.g., workers during rush hours)
  - subways, trains which go through long tunnels, aircraft are particularly vulnerable
  - subways have been terrorist targets
    - AUM sarin attack on the Tokyo subway
    - bombings on the Paris subway

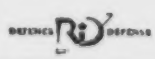
Other Possible Targets

- shopping malls
- office buildings
- indoor stadium/arena
- companies/locations involved in genetic engineering, especially of food products
- medical facilities/clinics
  - incidents at abortion clinics
  - facilities using experimental animals
- venues of high profile meetings or events
- prominent individuals
- food or drink in manufacturing, transport, wholesaling, retailing or restaurants
  - terrorist contamination of food in Oregon restaurants



Possible Dissemination Devices

- preferred devices will be:
  - adequate for the intended aim
  - easy to obtain or construct from readily available materials
  - easy to transport
  - unobtrusive in intended setting
- devices may or **may not** be explosively activated
  - biological materials are fragile and do not easily withstand explosive dissemination



Possible Dissemination Devices

- easily ruptured containers (e.g., glass flasks)
- gas cylinders
- adaptations of munitions
- enhanced improvised explosive devices
- sprayers (handheld, industrial, agricultural)
- actual munitions

Cylinders

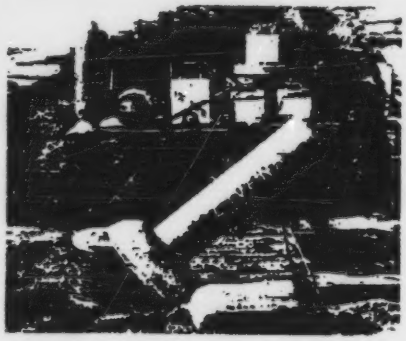
- used to release chemicals in WWI
- toxic industrial chemicals are shipped in cylinders of various sizes
- cylinders are readily available in a variety of sizes and materials
- commonly used in industrial or medical settings
- contents released by opening valve either manually or explosively

Easily Ruptured Containers

frangible hydrocyanic acid grenade

- Japanese WWII munitions of glass or porcelain
- use of light bulbs filled with simulant in subway trials
- AUM used heat sealed plastic bags which were easily punctured
- variety of containers/bags readily available

Adaptation of WWI Livens Projector



Livens projector

- easily manufactured
- drawings available

Livens projectile
cross sectional view; central tube contains explosive charge, detonated by contact fuze; ~30 lbs of agent

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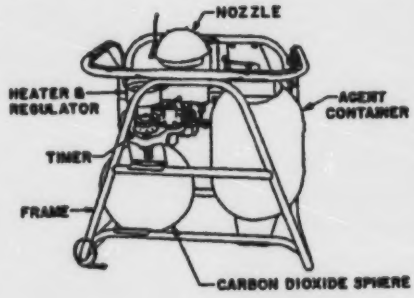
Generator, BW Portable, Liquid, E2

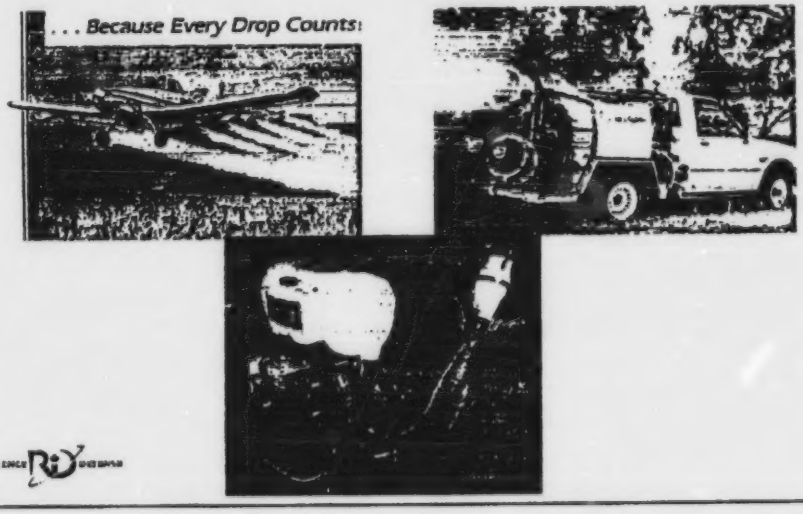


- agent: BW liquid
- back pack
- one man portable
- two fluid nozzle
- agent capacity 2.62 litres
- operating time ~ 7 min
- operating pressure 137 PSI
- delay time fusing 15 min - 8 hrs
- filled weight 35 lbs
- hxwxd: 16.2x18.7x10.7 in

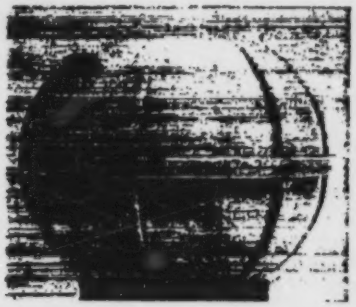
Fourth Consolidated Report of BW/CW Study (U), Dept. of the Navy, Bureau of Naval Weapons, NAVORD Report 6954 (First Revision) 31 March 1961

DRES

Agricultural Sprayers



Bomb, Biological, M143 (E134)



- anti-crop, anti-animal, anti-personnel
- liquid fill, 3.4 inch diameter
- impact fused, explosive atomization
- released from cluster bombs, dispensers, missile warheads

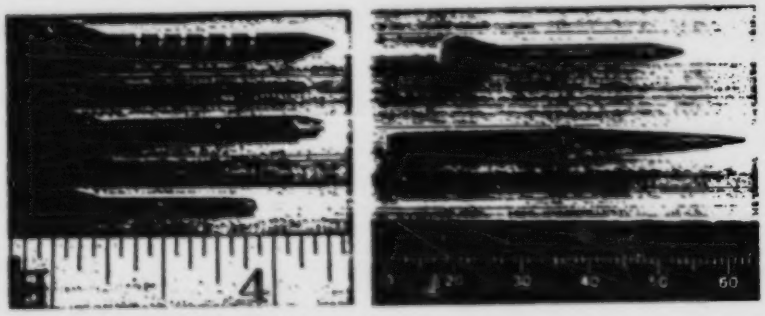
Bomb, Biological, E120

- anti-crop, anti-animal, anti-personnel purpose
- 4.5 inches diameter, liquid fill
- vaned outer shell provides rotation during flight
- used in cluster bombs or released from SUU-24 type dispensers
- upon impact, the outer shell shatters and the device rolls itself over spraying biological agent from the nozzle on top

Flechettes

- conventional flechettes are in the military arsenal of several nations
- chemical and biological flechettes have been developed and are described in the open literature
- flechettes have been used in assassinations:
  - shards in fragmentation grenade used to assassinate Heydrich were coated with botulinum toxin
  - pellet used to assassinate Georgi Markov contained ricin
  - saxitoxin was considered for use in small arms bullets for Special Operations forces
- coating of shards, nails or screws used in terrorist devices (e.g., bombs) has been suggested and would greatly increase the lethality of these devices

Flechettes



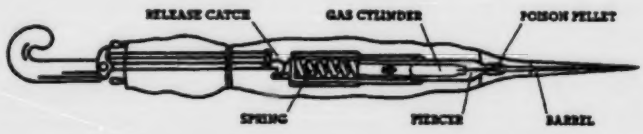
- anti-personnel
- exterior can be grooved to hold a heavy gluey quantity of agent or drilled internally to hold either liquid or dry agent
- packed by hundreds into a projectile

Markov Assassination

MEDICO-LEGAL SOCIETY

At a meeting of the Society held at the Royal Society of Medicine on Thursday 13th March 1980. The new President Mr. Leonard Caplan, Q.C. was in the Chair.

GEORGI MARKOV — DEATH IN A PELLET



Umbrella Gun - KGB

ricin was inserted in the holes in the pellet

Machined Sphere
68/1000ths inch diam.

INTERNET Suggestion for Terrorist Pipe Bomb

"Well, that's about all there is to the basic pipe bomb recipe. Of course there are all sorts of enhancements you can make to increase the effectiveness of the device, such as scoring the casement for better fragmentation, **coating with ricin or other suitable toxic agent to improve the kill-to-wound ratio**, etc. but the above recipe is intended for beginners."

Slack, The Bangster

newsgroups:alt.engr.explosives
morcegao@aol.com (Morcegano)

Chemicals Attractive to Terrorists

- commodity toxic gases (chlorine, ammonia, hydrogen cyanide, phosgene)
- organophosphorus and carbamate insecticides
  - solids or low volatility liquids
  - used on a large scale in agriculture (16,100,000 lbs used in California in 1997)
  - same mechanism of action as nerve agents
  - some have toxicities approaching G-agents
- cyanides

Biological Agents Attractive to Terrorists

- anthrax
- plague
- Q-fever
- *Salmonella*
- *E. coli*
- *Shigella*
- botulinum toxin

Sources of Chemical or Biological Agents

- for most terrorist attacks the amount of agent required is not large (<10 kg)
- agent may be:
  - purchased
    - from legitimate suppliers
    - black-market sources
  - made
    - chemical agents are easily synthesized; detailed information is available in the open literature
    - biological agents can be cultured
  - stolen
    - from manufacturers, laboratories, hospitals

Possible Scenarios

- hurling of a flask containing bacteria onto tracks just as train enters subway station
- detonation of a bomb containing contaminated shards
- introduction of toxic material into ventilation system of office building or shopping mall
- contamination of food served in restaurant or sold in supermarket with bacteria
- "accident" in a chemical or biological laboratory (curious or disgruntled student)

Conclusions

- terrorists have attacked the public with chemical and biological agents
- attacks will continue!!!
- agents and dissemination devices are readily available
- number of potential targets is increasing
- **EXPECT THE UNEXPECTED!!!!**

Section 8:

Hogtown Disaster: A Biological Terrorist Attack on a Major Canadian City

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DEFENCE R&D DÉFENSE

Hogtown Disaster

A BW Terrorist Attack on a Major Canadian City

Canada

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Outline

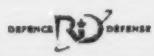
- background
- question
- classification of terrorist groups
- minimum requirement for a chemical or biological attack
  - scenario considerations
  - agent selection
  - dissemination equipment
  - meteorological considerations
- selected scenario
- modeling of scenario
- conclusions

Background

Kaufmann, Meltzer and Schmid[1] of the Centers for Disease Control and Prevention considered the economic impact of a bioterrorist attack on a suburb of a major city

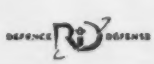
- projected impact is based on 10% or 100% of target population of 100,000 exposed to aerosol cloud
- exposure to *Bacillus anthracis, Brucella melitensis,* or *Francisella tularensis* is considered
- economic impact ranges from an estimated $477.7 M per 100,000 persons exposed for brucellosis scenario to $26.2 B per 100,000 persons exposed for anthrax scenario
- rapid implementation of post attack prophylaxis program is the single most important means of reducing these losses

1 A.F. Kaufmann, M.I. Meltzer and G.P. Schmid, "The Economic Impact of a Bioterrorist Attack: Are Prevention and Post Attack Intervention Programs Justifiable", Emerging Infectious Diseases, 3 (1977) (www.cdc.gov/ncidod/EID/vol3no2/kaufman.html)



Question

- Could a domestic terrorist group cause in excess of 10,000 casualties by releasing a biological agent in the countryside surrounding a major urban center?



Classification of Terrorist Groups

- state-supported group
  - essentially Special Forces operations of a foreign government
  - limited by technical/logistical expertise of the sponsoring government
- domestic group
  - formed for single event
  - formed for long term
- individual with specific technical expertise
  - may be very difficult to detect
  - has expertise to design effective scenario
  - has ready access to agent, dissemination devices, protective equipment, etc.

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- ideally, has members with bachelor's degrees or technical school diplomas in health sciences, microbiology, chemistry or chemical engineering, mechanical engineering, atmospheric physics or meteorology, and computer science
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- front as legitimate company engaged in:
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  - greenhouse operations
  - medical diagnostics laboratory
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- front provides:
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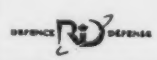
- to plan and execute a CB attack, the terrorist group would, as a minimum, need to be able to:
  - develop a credible attack scenario/concept of use
  - identify candidate agents
  - obtain sufficient agent for the attack
  - obtain a suitable delivery system
  - have a basic understanding of the effect of meteorology
  - understand the protective measures which must be employed to safely use the selected agents

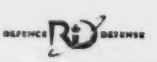
Scenario Considerations

- aerosol dissemination is normally required to produce high casualty numbers (e.g., >10,000)
- high population density is required in target area
  - urban area
  - outdoor event (e.g., concert, rally, sports)
- target population is normally outdoors or in buildings with the windows open
  - releases in mild weather
  - releases in areas where efficiently filtered air conditioning systems are not the norm in residential housing



Biological Agent Selection Criteria

- agent can be effectively disseminated as an aerosol
  - robust
  - low agent decay rate
- sample culture is readily available
  - from natural sources
  - standard reference sample
- agent is
  - relatively easy to produce without special equipment
  - sufficiently infective
  - has predictable incubation period
- resulting disease is difficult to diagnose and treat



Biological Agent of Choice

Bacillus anthracis

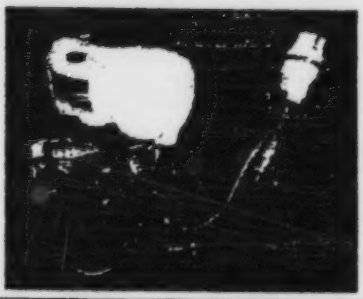
- bacterium forming stable spores
- non-transmissible
- inhalation (ingestion) hazard
- moderate infectivity, very lethal, incubation period of 1-5 days, illness lasts 3-5 days
- diagnosis extremely difficult because of non-specific initial presentation
  - chest X-ray classical in late stages
  - serology usually only useful retrospectively

Agent Preparation

- autoclave requirement
  - pressure cooker
  - construct out of pressure piping, valves, regulators
- culture containers
  - milk churns
  - quart sealers
- growth medium for anthrax
  (1) molasses, charcoal, marmite, $NaH_2PO_4 \cdot 2H_2O$
  (2) potato medium
  (3) corn steep liquor
  (4) medium G

Dissemination Equipment

- commercially available agricultural spray equipment with nozzles/pressures selected to produce very small diameter drops (e.g., Micronair sprayer)
- suitable enclosed vehicle to hold equipment



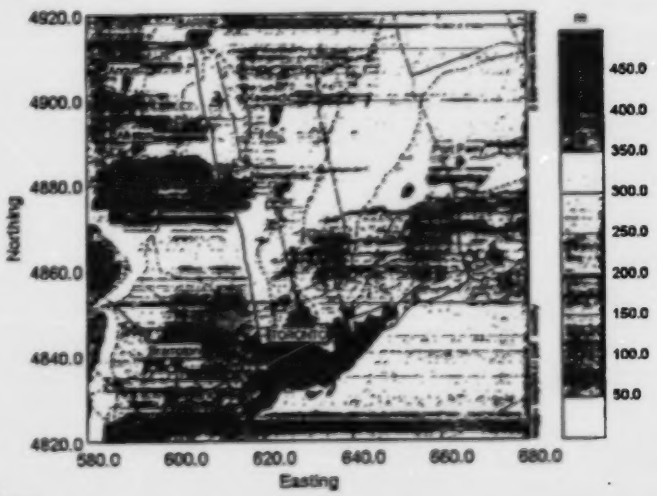
Meteorological Considerations

- night attacks favored
  - lower agent decay at night
- relatively constant wind direction (∓30°)
- reasonable wind speed (2-5 m/sec)
- no precipitation
- current and historical meteorology for target location readily available
- should be able to predict wind speed and direction from that at midnight

General Scenario

- agent is released as a long line source from a moving vehicle at night in the summer upwind of a suburban area and drifts on a relatively constant wind over the suburb
- possible target areas include:
  - metropolitan Toronto
  - Montreal Island
  - lower Fraser Valley - metropolitan Vancouver
  - Ottawa

Terrain in the Vicinity of Metropolitan Toronto



DRES

Toronto Census Atlas 1996

Source: Statistics Canada 1996 Census

DRES

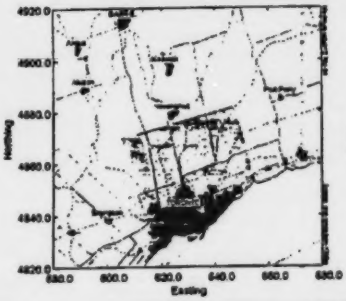
Model and Input Parameters

- model
  - HASCAL/SCIPUFF (second-generation complex terrain probabilistic output CBW hazard assessment model)
- input parameters
  - agent = wet anthrax (3% dry weight solid)
  - agent quantity = 100 litres
  - line length = 43 km
  - release duration = 30 min
  - release time 2300 hrs or midnight
  - agent decay 0.2%/min (night); 2%/min (day)

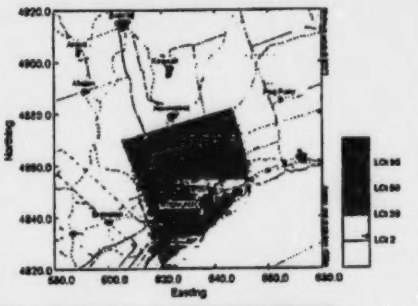
DRES

Release on 10 July 1998 at Midnight

1% dissemination efficiency



10% dissemination efficiency

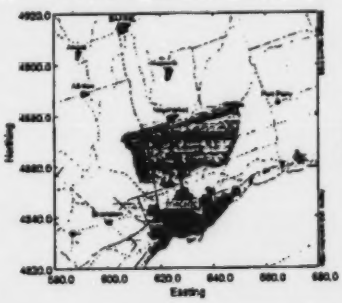


Time	Wind Speed (m/s)	Wind Direction (deg N)	Time	Wind Speed (m/s)	Wind Direction (deg N)
00:00	8.2	338	04:00	4.6	338
01:00	5.1	0	05:00	5.1	338
02:00	4.6	0	06:00	5.1	338
03:00	4.6	338			

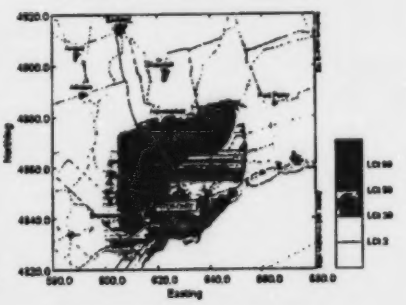
DRES

Release on 06 July 1998 at Midnight

1% dissemination efficiency



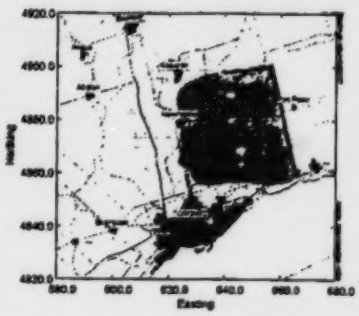
10% dissemination efficiency



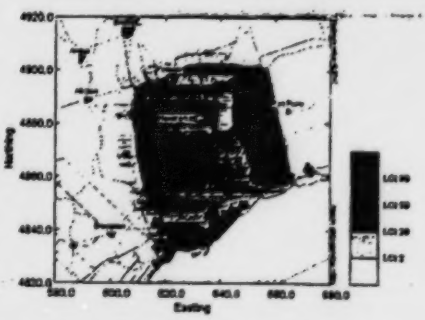
Time	Wind Speed (m/s)	Wind Direction (deg N)	Time	Wind Speed (m/s)	Wind Direction (deg N)
00:00	1.0	247	04:00	1.5	0
01:00	1.0	337	05:00	1.0	337
02:00	1.0	0	06:00	0.0	0
03:00	1.5	0			

Release on 07 July 1998 at 23:00 hrs

1% dissemination efficiency



10% dissemination efficiency



Time	Wind Speed (m/s)	Wind Direction (deg N)	Time	Wind Speed (m/s)	Wind Direction (deg N)
23:00	2.1	67	03:00	1.5	67
00:00	1.5	90	04:00	2.6	67
01:00	2.6	90	05:00	2.1	67
02:00	2.1	67	06:00	2.1	45

Observations

- The attack, itself, should go undetected until the first casualties present for medical care
- It is highly unlikely that the initial casualties will be accurately and rapidly diagnosed as the initial clinical signs of exposure to inhalation anthrax are non-specific

Conclusions

- A domestic terrorist group using readily available information could produce sufficient agent (in this case anthrax) and disseminate it effectively in the area surrounding a major urban center so as to cause casualties in at least 20% of the exposed population

The Defence Research and Development Branch provides Science and Technology leadership in the advancement and maintenance of Canada's defence capabilities.

DEFENCE R&D DÉFENSE

Section 9a:

Management: Detection of Chemical Warfare Agents

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DEFENCE R&D DÉFENSE

Detection of Chemical Warfare Agents

Canada

Initial Detection of Chemical Warfare (CW) Agents by First Responders

- based on the presentation of casualties of the CW agent attack
- must take into account:
  - the situation and history of the scene
  - witness descriptions

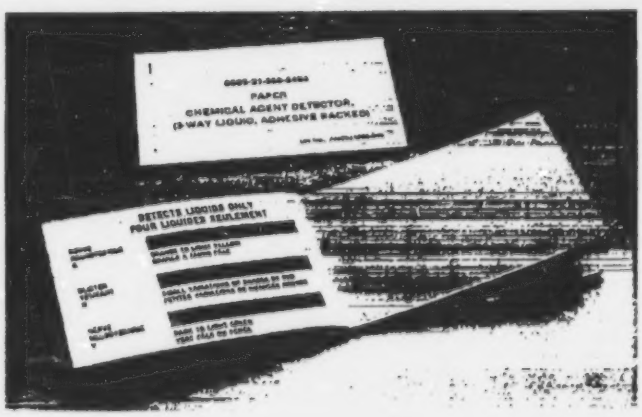
DRES

Chemical Warfare Agent Detectors

- are all military devices
- some are available to civilian agencies
- not all are useful to a "First Responder"
- training is required in their use
- any results obtained are all subject to interpretation by a skilled operator.

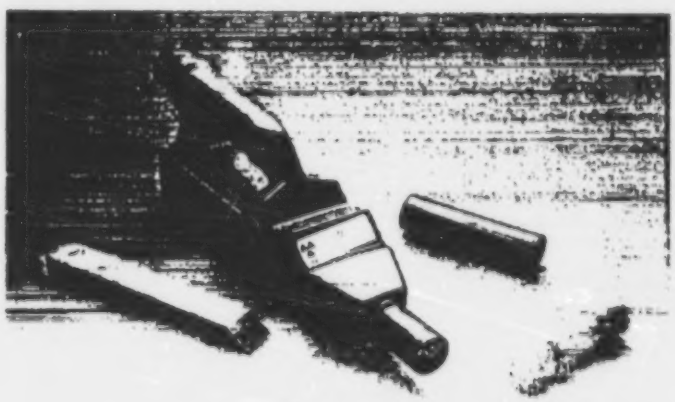
DRES

3-Way Detector Paper

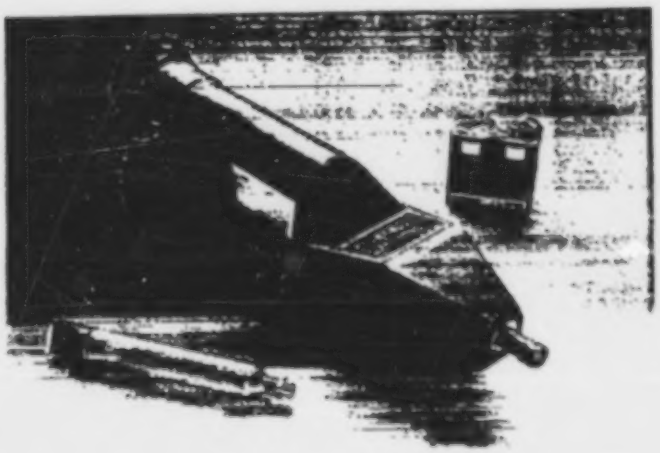


3-Way Detector Paper

Chemical Agent Monitor - CAM

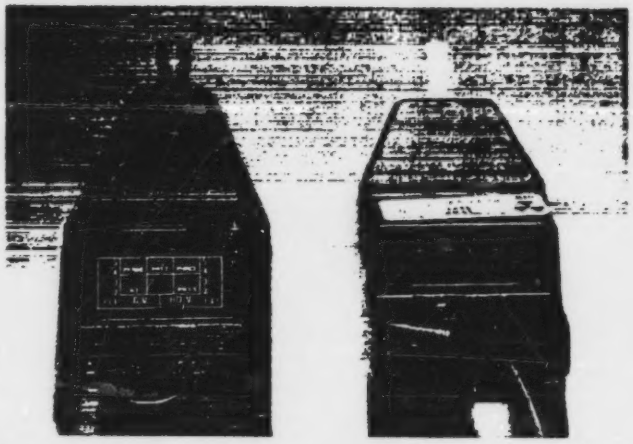


AP2C



CAM and AP2C Detector Comparisons

CAM and AP2C Display Comparisons

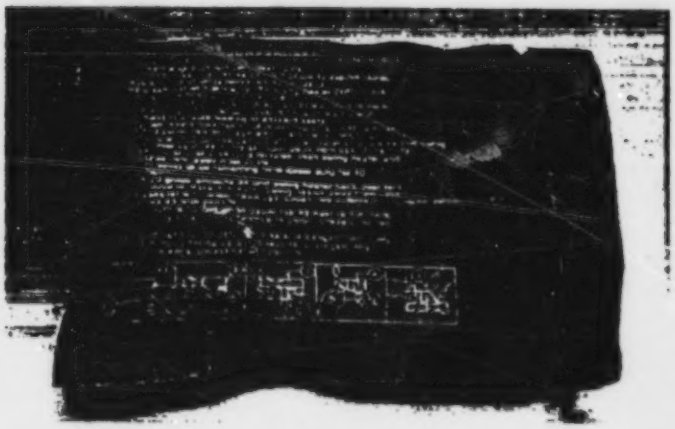


Nerve Agent Vapor Detector NAVD

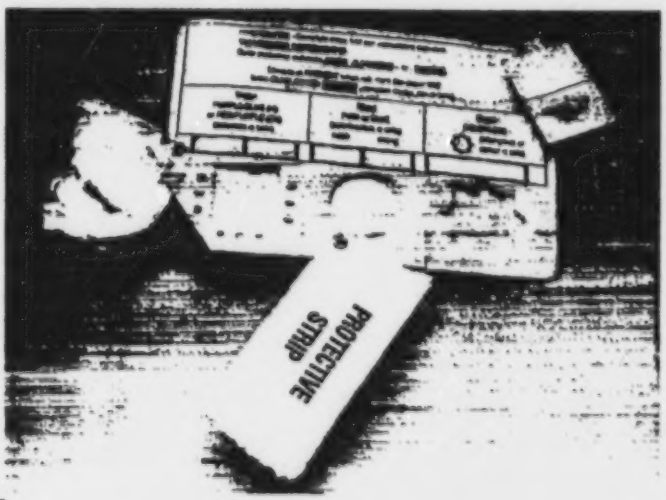
NAVD - In use

M 256 Kit (U.S.)

M 256 Kit (U.S.)



M 256 Kit (U.S.)



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Section 9b:

Management: Detection and Identification of Biological Warfare Agents

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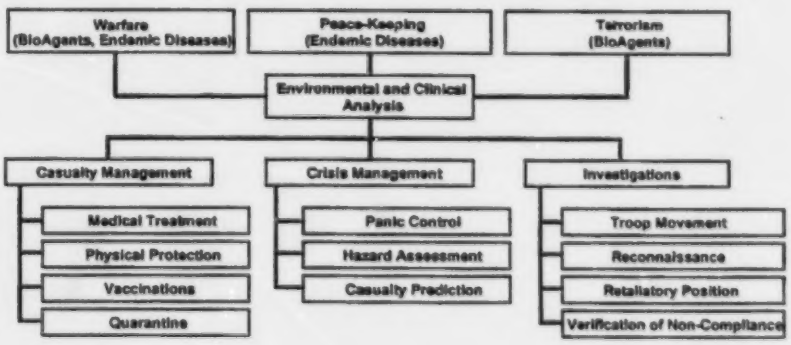
DEFENCE R&D DÉFENSE

Detection and Identification of Biological Warfare Agents

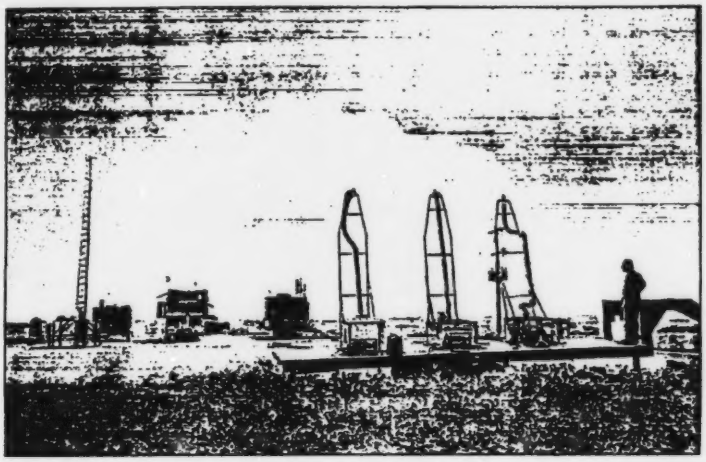
Canada

DRES

Military Identification Requirements



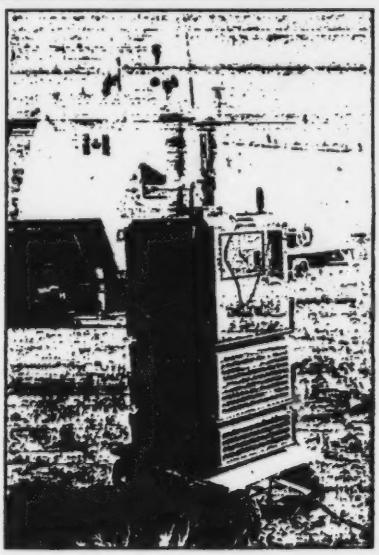
DRES



DEFENCE R&D DEFENSE

DRES

CIBADS 1995-1999



DEFENCE R&D DEFENSE

CIBADS Project Overview

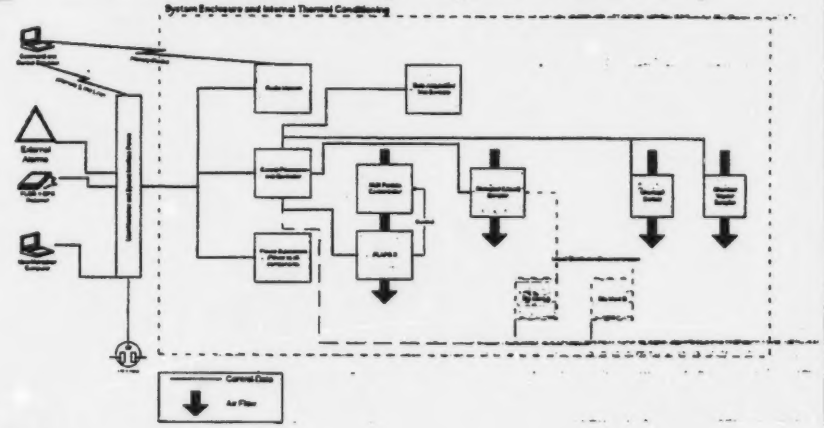
Phase 1 Detailed Project Plan (complete)

Phase 2 CB Sentry (complete)
- Phase 2a - Prototyping and Integration
- Phase 2b - Optimization

Phase 3 CB Ident (Aug 1997 - Oct 1999)
- Phase 3a - Prototyping and Integration
- Phase 3b - Optimization

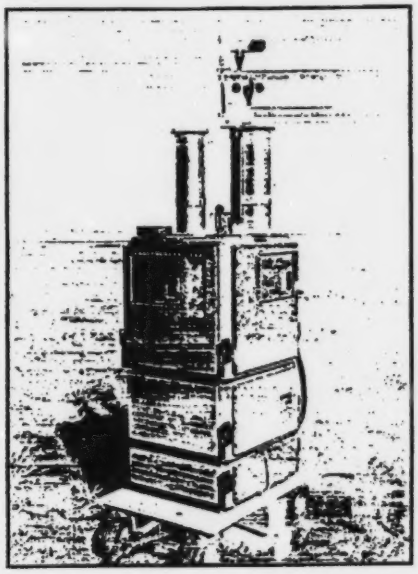
Phase 4 CB Detector (Aug 1999 - Dec 2000)
- Integrate CB Sentry and CB Ident
- Deliver 2 ADM Units

CIBADS II CB Sentry
Mk2 Architecture (Project Phase 2b)



DRES

CB Sentry
(Project Phase 2b)



DRES

CB Sentry Performance at JFT IV

- 21 Scored Trials
- Simulant: BG (anthrax spore simulant)
- Detection Probability
  - ≤ 15 ACPLA 1
  - > 15 ACPLA 1
- Time to detect 18 sec
- False Triggers 0

U.S. JAA Conclusion: "CIBADS Units performed best of all candidate technologies tested"

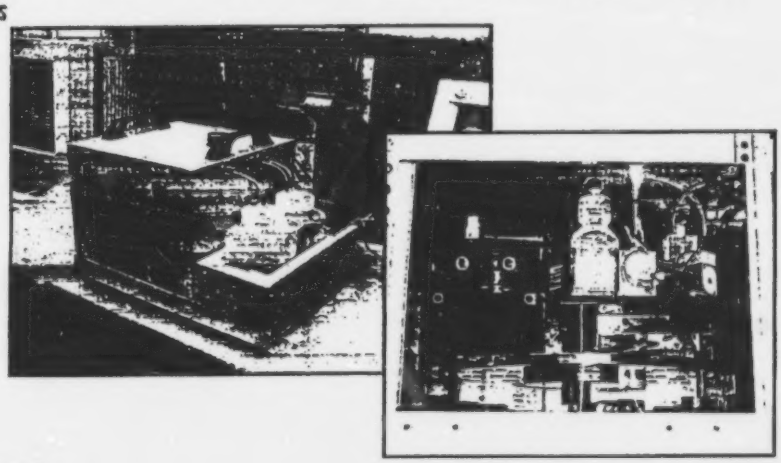
Military Identification Requirements

- real-time identification capability in the automated CB sentry system (antibodies and PCR) for early warning capability around strategic locations within the theatre of operation or for reconnaissance missions
- clinical diagnostic and environmental analysis capability within the theatre of operation (field hospitals) and outside theatre of operation (reference laboratories)

Field Identification - CIBADS

- Requirement: two independent, complimentary technologies for BW agent identification
- Primary: Immunochromatographic Assays
  - Automated Ticket Reader Variants
    - bench top for lab-based identification or diagnosis
    - integrated for automatic sample processing
- Complimentary Technology: likely genetic analysis
  - adopt a progressive development where capability will be first instituted in lab then field lab and eventually integrated into CIBADS

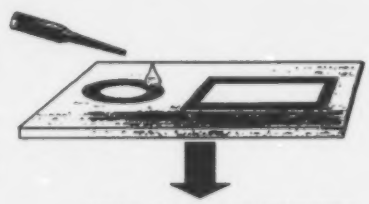
Phase 3a Automated Ticket Reader



Antibody-Based Hand-Held Assay: *Procedure*

1. **Add liquid sample to device**

   Serum, urine, saliva, collected air or other environmental sample



READ AFTER 15 MINUTES

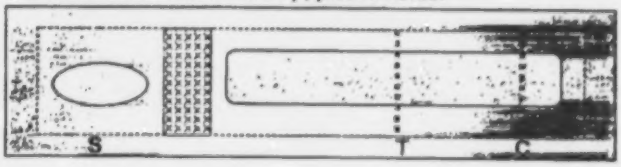
2. **Positive Test**

3. **Negative Test**

Antibody-Based Hand-Held Assay: *Mechanism*

HHTK Configuration

Nitrocellulose membrane strip; plastic holder

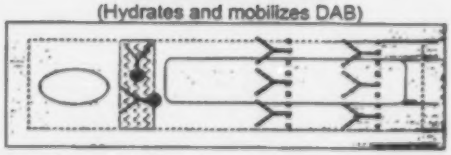


S	Sample well
	Detector AB (DAB) pad
T	Test line
C	Control line

Antibody-Based Hand-Held Assay: *Mechanism*

Add liquid sample

(Hydrates and mobilizes DAB)



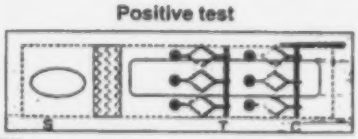
- Anti-agent AB (DAB)
- Colloidal gold
- Anti-agent AB
- Anti-species AB

Direction of wicking

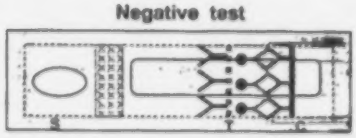
Reaction Time
15 minutes

Results

Positive test



Negative test



CDC URBAN 4WARN

CIBADS in a station wagon

Section 9c:

Management: Decontamination of Chemical/Biological Agents and Contamination Control

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DEFENCE R&D DÉFENSE

Decontamination of Chemical/Biological Agents and Contamination Control

Canada

DRES

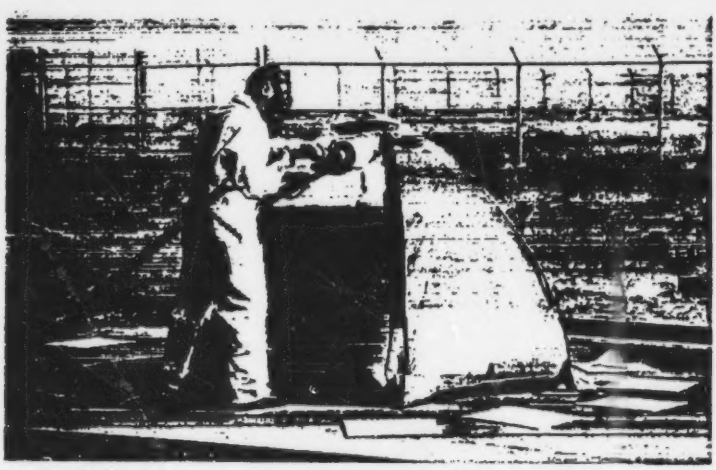
Outline

- specific decontamination products and supplies available to first responders and the military
- commonly available chemicals and supplies that can be used to decontaminate chemical and biological warfare agents
- decontaminants in development

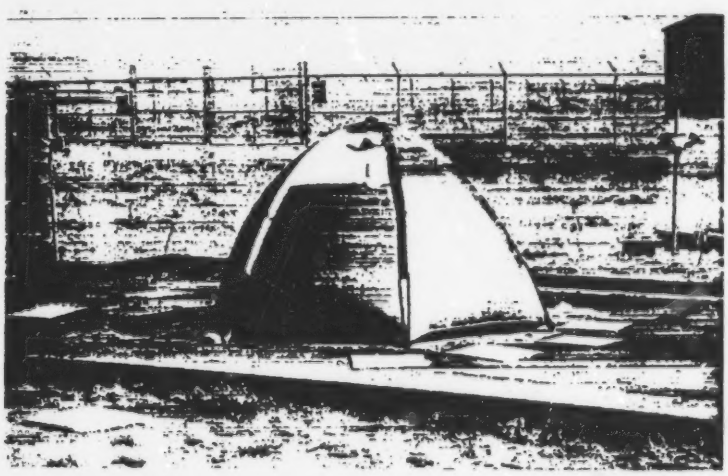
Blast-Guard™

- water-based foam that can be mixed in the field and used to smother chemical or biological explosive devices
- foam absorbs the explosion and traps fragments
- decontaminant in the foam destroys chemical warfare and biological agents released by the dissemination device

Blast-Guard™ tent with an optimized terrorist explosive dissemination device inside prior to detonation



filling the tent with the Blast-Guard™ foam mixture



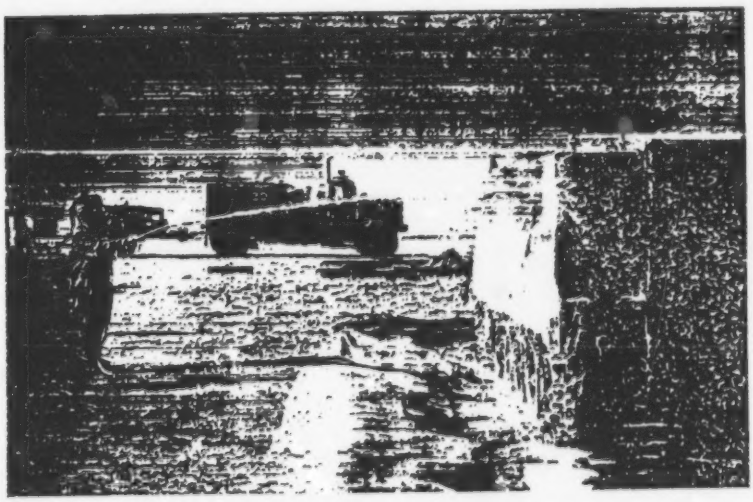
tent after detonation of simulated terrorist device

CASCAD™

Canadian Aqueous System for Chemical/Biological Agent Decontamination

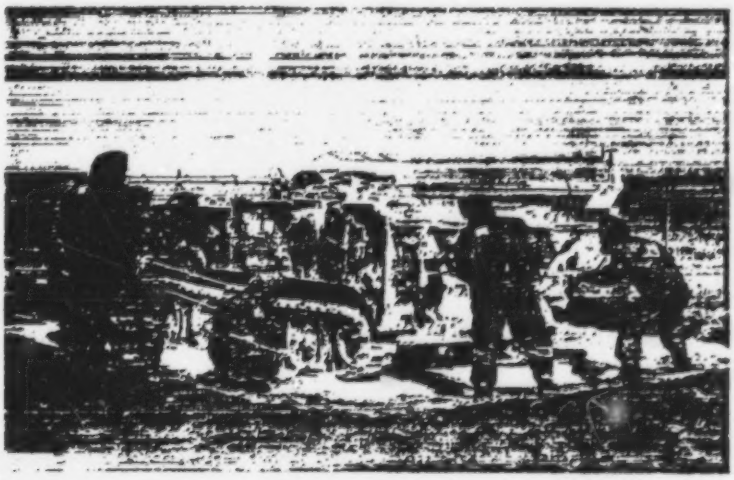
- water-based foam that can be mixed in the field and sprayed onto vehicles and equipment using specialized equipment
- foam adheres to and coats contaminated surfaces to reduce the downwind vapor hazard of CW agents
- destroys all chemical warfare and biological agents

CASCAD™



DRES

CASCAD™



DRES

Expedient Decontaminants for Chemical and Biological Warfare Agents

- bleach
- dilute sodium hydroxide
- super tropical bleach (STB)
- high test hypochlorite (HTH)
- swimming pool "Slow Release Chlorine"

Expedient Decontaminants

sources of expedient decontaminants

- swimming pool supply houses
- janitorial supply houses
- hardware stores
- grocery stores

Bleach

- sodium hypochlorite
- only available as a solution with water
  - 4% residential
  - 6% commercial
  - 10.8% swimming pool supply
- effective against nerve agents
- highly effective against all biological agents even in dilute solutions

Bleach

- slower reactivity with mustard due to poor solubility
- used at DRES in field trials as a CB suit decontaminant on decontamination line
  - foot bath
  - glove rinse
  - general spray on CB suit
- undiluted bleach should not be used on skin

Sodium Hydroxide

- available as solid pellets that absorb moisture on contact with air
- must be dissolved in either water or alcohol to be an effective decontaminant for CW agents
- highly corrosive
- cannot be used on skin
- effective decontaminant for biological and nerve agents

Sodium Hydroxide

- slower reactivity with mustard due to poor solubility
- typical concentrations of 10% w/v in either water, methanol, ethanol or isopropanol make an effective decontaminant
- sodium hydroxide/methanol solutions are used at DRES as a general laboratory decontaminant for CW agents

Super Tropical Bleach and High Test Hypochlorite

- calcium hypochlorite
- available as a reactive powder that can be used directly on liquid agents, but is most effective against CW agents when mixed with water to form a slurry
  - 60% STB or HTH with 40 % water
- effective against all chemical and biological agents

Super Tropical Bleach and High Test Hypochlorite

- powerful oxidizer with ~90% active chlorine content
- must be handled, stored and treated as a "hazardous material"
- can produce spontaneous combustion when mixed with a sufficient quantity of fuel
- respiratory protection is required when handling or mixing this material

Swimming Pool "Slow Release Chlorine"

- alternate names:
  - sodium dichloro-s-triazinetrione
  - sodium dichloroisocyanurate
  - Fichlor®
  - CBD Clearon®
- one of the reactive ingredients used in the CASCAD™ decontaminant system

Swimming Pool "Slow Release Chlorine"

- can be mixed 10% w/v with water to form an effective decontaminant for biological and nerve agents
- slower reactivity with mustard due to poor solubility
- dry chemical is stable when stored dry
- active chlorine content ~60%
- not classified as a "hazardous material" for transportation, storage or use

Absorbent Materials

- can be used to contain gross liquid CW agent contamination
- will reduce the vapor hazard
- examples
  - Fuller's Earth
  - Diatomaceous Earth
  - Hazmat Spill Kit products
  - "Kitty Litter"
- CW agents absorbed on material are still present and must be destroyed in a separate operation

Reactive Skin Decontaminant Lotion (RSDL)

- only decontaminant designed for use on intact and/or damaged skin surfaces
- destroys known chemical warfare agents
  - preferentially destroys nerve agents
  - effective against vesicant agents
- has not been approved for use in Canada

Reactive Skin Decontaminant Lotion (RSDL) - What Is It?

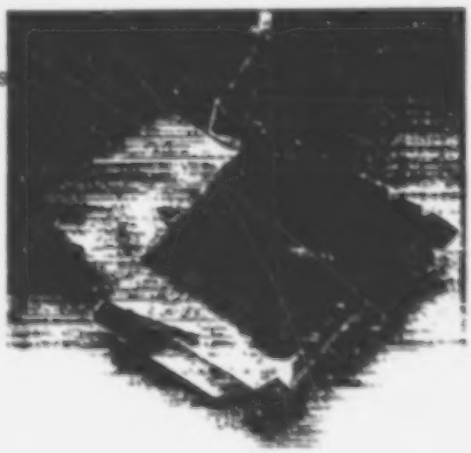
- RSDL is a viscous lotion that is applied by hand (or gloved hand) to skin surfaces
- RSDL is available in single use green pouches with foam applicator (45 ml of liquid) and 100 ml and 500 ml bulk liquid for larger area medical decontamination
- training lotion that contains *no active ingredients* is also available in blue pouches
- the level of training required to use RSDL is about the same as that needed to apply suntan lotion

Reactive Skin Decontaminant Lotion (RSDL)

RSDL is available in single use green pouches with foam applicator (45 ml of liquid) and 100 ml and 500 ml bulk liquid for larger area medical decontamination

Reactive Skin Decontaminant Lotion (RSDL)

foam applicator is used to dispense the RSDL and to scrub contaminated surfaces



Reactive Skin Decontaminant Lotion (RSDL)

- can be applied to the eyes and mucous membranes
- can be left on the skin for extended periods without irritation
- is water soluble and easily removed with a water rinse
- once on the skin, provides a barrier to further CW agent contamination

Conclusions

- decontamination products and chemicals that are effective against both chemical and biological warfare agents are available to first responders
- the problems of contamination control and decontamination are not insurmountable for trained and knowledgeable personnel

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Section 9d:

Management: Personal Protective Equipment and the Chemical Warfare Agent Contaminated Environment

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DEFENCE R&D DÉFENSE

Personal Protective Equipment and the Chemical Warfare Agent Contaminated Environment

Canada

Canadian Integrated Protective Equipment (IPE)

- CB protective coverall
- Canadian (CA) C4 gas mask
- C-7 canister
- chemical protective gloves
- chemical protective overboots

Canadian Chemical-Biological Protective Coverall

- single piece coverall designed to prevent chemical warfare (CW) agents from penetrating and coming in contact with the skin
- covers the entire body except for the face, hands and feet
- can be removed in such a manner as to prevent skin contact with the contaminated external surfaces of the suit

Hazardous Materials Suit

- hazardous materials suit serves the same function as the CB coverall and function in a similar manner
- DRES has tested the TyChem 1000 suit material for the NBC School and found that **liquid mustard** does not penetrate it
- other suits using the same materials would also be similarly resistant to **mustard** penetration

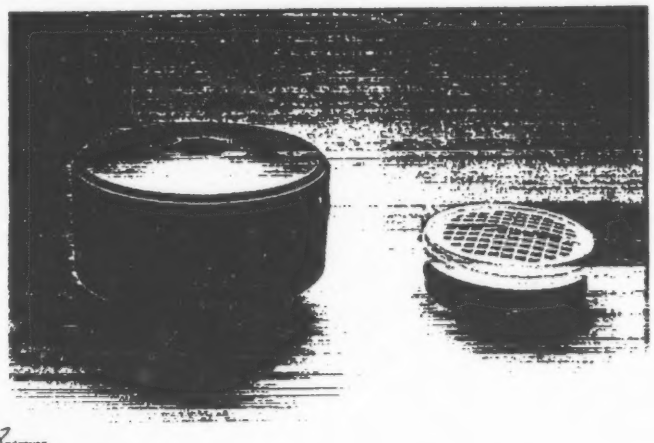
Canadian C4 Gas Mask

- completely covers the face
- protects the eyes from CW agent vapour and liquid while providing good visibility
- provides a source of filtered and purified air to the wearer

Why Should a Gas Mask Protect the Eyes?

AGENT	STATE	VOLATILITY (mg/m^3)	TOXICITY ($mg.min/m^3$)		VAPOUR DENSITY (x air)
			LCt50	ICt50	
H	liquid	610 (20°C)	1500 inhale 10000 skin	200 eye 2000 skin	5.4
L	liquid	4480 (20°C)	1200 inhale 10000 skin	300 eye 1500 skin	7.1
HN1	liquid	1520 (20°C)	1500 inhale 20000 skin	200 eye 9000 skin	5.9
GA	liquid	610 (25°C)	400 inhale	0.5 eye 300 inhale	5.6
GB	liquid	20000 (25°C)	100 inhale	0.5 eye 75 inhale	4.9

C7 Canister Compared to a Commercially Available Product



First Responder Self-Contained Breathing Apparatus

- the same level of protection afforded by the C4 mask can be had through the use of a self-contained breathing apparatus
- does everything that a C4 mask does
- advantages
- disadvantages

First Responder Self-Contained Breathing Apparatus - Advantages

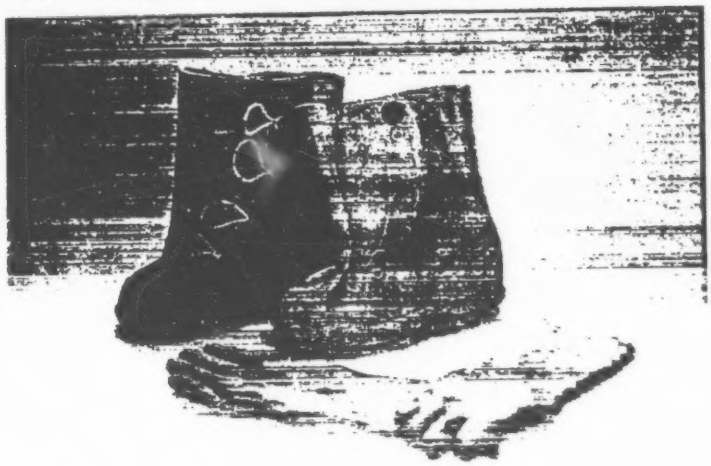
- available to hazardous material personnel and firemen who are trained in its use
- can be used in environments that have reactive gases or are depleted in oxygen
- can operate at a slight positive pressure to reduce the risk of chemical vapor entry
- the weight of the mask on the face seal is less, reducing the risk of air seepage

First Responder Self-Contained Breathing Apparatus - Disadvantages

- limited air supply
- overall weight is substantially more than a gas mask
- may not be easily decontaminated
- may not be as easily removed as a gas mask at a decontamination station

DRES

CW Gloves and Boots



DRES

CW Gloves and Boots

- CW boots and gloves are the only part of the IPE system that is meant to get grossly contaminated in use
- in any CW agent contaminated environment almost all of the contamination will be on the ground in direct contact with the boots
- gloves allow the wearer to do necessary work safely in the contaminated environment

CW Gloves and Boots

Specifications:

- minimum thickness: 1.1 mm
- mustard penetration: less than 10 μg/cm² in 24 hours
- made from butyl rubber with a protective outer surface layer of neoprene rubber
- CB protective coverall covers open ends of the gloves and boots preventing CW agent entry

Rubbers and Chemical Warfare Agents

Worst Performers in General

- natural rubber latex
  - latex rubber gloves
  - medical examination gloves
- vinyl gloves
  - polyvinyl chloride (PVC)
  - polyvinyl acetate (PVA)
- neoprene
  - polychloroprene

Rubbers and Chemical Warfare Agents

Medium Performers in General

- Nitrile
  - typical **mustard** breakthrough time of 15 minutes with medical examination grade gloves
- Viton
  - no breakthrough time observed with mustard but permeation by nerve agents reported in the literature

Rubbers and Chemical Warfare Agents

Best Performers in General

- butyl rubber
- bromobutyl rubber
- chlorobutyl rubber
- breakthrough time and penetration characteristics depend on:
  - thickness of the rubber
  - number of layers used
  - method of construction

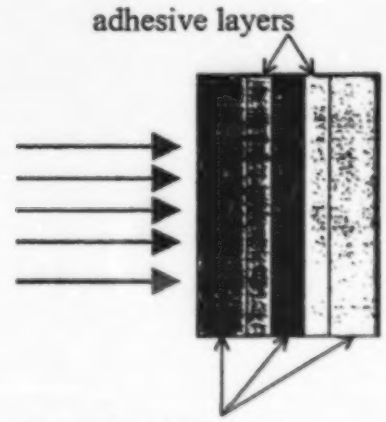
Gloves and Boots for First Responders

- gloves and boots having a butyl rubber layer that is not penetrated by stitching will have some degree of CW agent resistance
- rubber material used on gloves and on the sole or exterior surfaces of boots may absorb CW agents directly into the rubber where it cannot be easily decontaminated
- in most cases normal hazardous material boots and gloves can be used
- in many cases standard boots and gloves can be used if a CW agent impermeable liner is used between the skin and the boot or glove
  - the glove or boot must be recognized as "contaminated" and remain on the "dirty" side of the decontamination line

Barrier Laminate Material

- multiple layers made from various plastics having different chemical affinities
- examples of some polymers used:
  - nylon (polyamide)
  - polyethylene (PE)
  - polyethylene alcohol (EVAL)
  - polyethylene terephthalate (PET, Mylar)

Typical Laminate Layer Cross-Section



different polymer layers in laminate material

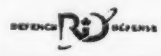
Barrier Laminate Material

Specific Examples

- RCMP heat sealable evidence bags
  - PE/PET/Nylon
  - no penetration observed when tested against mustard and GB (liquid and vapour)
- 4H glove and boot liners (www.safety4.com)
  - PE/PEAL/PE
  - used in the hazardous material industry
  - meets CW glove and boot specification when tested against liquid mustard
    - 1.5 μg/cm² penetration in 24 hours
  - no observable penetration by agent when tested against liquid GF

Conclusions

- First Responders must be aware of the problems that may occur in using protective equipment in a CW agent contaminated environment
- solutions to these problems exist
- First Responders must know about these solutions and how to implement them



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Summary Information Sheets

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SUMMARY INFORMATION SHEETS

The following information has been prepared as a summary to provide critical information to first responder and medical staff. **It is to be used for information purposes only.**

NERVE GASES, NERVE AGENTS (G Agents, V Agents)

All are liquids at room temperature, look like water and are organophosphorus compounds.

LETHAL: WILL LEAD TO DEATH IF NOT TREATED IMMEDIATELY

G AGENTS – HIGHER VAPOUR HAZARD

- ***GA*** Tabun
- ***GB*** Sarin
- ***GD*** Soman
- ***GF***

V AGENTS – **VX** HIGHER LIQUID HAZARD

Routes of Poisoning

respiratory – lungs (fastest)
mucosal or moist areas (eyes, mouth)
skin (slowest exept for V-agents which can be extremely hazardous through skin absorption

Mechanism of Poisoning

impede normal nervous system activities
acetylcholinesterase enzyme inhibitor
accumulating acetylcholine leads to cholinergic symptoms

Nerve Agent Poisoning Signs and Symptoms

G AGENT – DEVELOP RAPIDLY AFTER EXPOSURE
(1 MINUTE TO 1 HOUR)

V AGENT POISONING – SIMILAR TO THOSE OF G AGENTS

Symptoms are listed in order of severity that is also an indication of the level of exposure:

(1) constricted pupils and dim vision;
(2) running nose, salivation;
(3) feeling of tightness in chest;
(4) muscular weakness;
(5) intestinal cramps and diarrhea;
(6) difficulty in breathing; and
(7) convulsions

Symptoms can include: dyspnea, rhinorrhea, cough, chest tightness, constriction of pupils, blurred vision, frontal headaches, salivation, vomiting, abdominal pains, muscle weakness, incoordination, laryngeal and bronchospasm, fasciculation, clonic convulsions, anoxemia, coma, incontinence, pulmonary edema, respiratory arrest.

Treatment of Organophosphate Nerve Agent Exposure

On-Site Consequence Management

First responder must have respiratory protection and avoid all liquid contamination by using gloves, boots and if possible vapor protective suits or plastic aprons. Gloves should be changed frequently.

The casualty must be fully decontaminated prior to moving. Prevention of further casualties is a top priority.

All clothing should be removed and double bagged to avoid further vapor hazard. Contaminated victims should not be transferred to the medical facility to avoid secondary casualties.

Medical manangement as described below can be used on-site by, or under the direction of, a physician.

Decontamination

A hypochlorite solution (household bleach diluted 1:10 with water) can be used to decontaminate patients. This should be followed by a liberal wash with soap and water.

Undiluted bleach can be used to wash instruments or contaminated gloves.

Treatment of Decontaminated Casualty

Basic principles of emergency medical treatment apply.

a. secure and manage the patient's airway;
b. suction the airway and administer oxygen;
c. start IV lines

Medical Treatment

In moderate to severe intoxications symptons (copious eye, nose, bronchi, and intestinal secretion to loss of consciousness, convulsions and apnea) can be managed as follows:

a. Atropine: 2 to 3 mg administered IM and IV q 3-10 min for cholinergic symptons;
b. Pralidoxime (PAM-2) 1-2 gms IV and/or IM bolus infusion at 0.5 g/hour, monitor AChE levels;
c. Diazepam 5-10 mg for convulsions;
d. cardiorespiratory monitoring; and
e. cardiac arrhythmia etc., as a function of the patient's general condition

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Medical Letter, Prevention and Treatment of Nerve Gas Poisoning, November 16, **1990**.

BLISTER AGENTS (MUSTARD, LEWISITE, NITROGEN MUSTARDS)

General Properties

liquids at room temperature
alkylating agents
designed as incapacitating agents
can lead to death as a result of the injuries they cause

Sulfur Mustard
H MUNITIONS GRADE MUSTARD
HD MUSTARD DISTILLED

Other Blister Agents
HN-3 NITROGEN MUSTARD
L LEWISITE

Routes of Poisoning

SKIN (ESPECIALLY SWEATY, HUMID AREAS)
EYES
LUNGS
GI-TRACT

Signs and Symptoms of Mustard Poisoning

Often symptoms are delayed 2 – 24 hours. This may make the initial detection of an agent attack more difficult to determine. Victims may not have any effects and spread contamination.

EARLY
- redness, inflammation, pain
- tearing, irritation of mucosal membranes, coughing, sneezing

LATER
- skin blister
- skin necrosis

INHALATION CAN LEAD TO PULMONARY OEDEMA AND SEVERE LUNG DAMAGE WHICH RESULTS IN DEATH

Mustard Symptoms Depend on the Site of Exposure

EYES

Vapor:

latent period of 4-12 hours
lacrimation, pain, blepharospasm
conjunctivitis, photophobia and eyelid edema

Liquid:

lacrimation, photophobia, blepharospasm, eyelid edema, conjunctivitis and pain

SKIN

latent period of 4-72 hours
pruritus, buring and erythema, pain, delayed vesiculation and edema
IF SEVERE secondary infection and systemic manifestations such as nausea, vomiting, pyrexia, confusion and shock

RESPIRATORY

nasal irritation, hoarseness, cough, sore throat, pharyngitis, bronchitis, cyanosis, purulent sputum, bronchopneumonia and resultant leukopenia

The effects of **Lewisite** are similar to the mustards but more immediate in manifestation and can be very painful.

Treatment of Mustard Exposure

On-Site Treatment

1. NO SPECIFIC ANTIDOTES EXIST
2. The person should be decontaminated as quickly as possible and transferred to a medical facility. All clothing should be removed and double bag to avoid further vapor hazard. Contaminated victims should not be transferred to the medical facility to avoid secondary casualities.
3. EYES: Immediate, rapid decontamination is imperative since ocular damage may occur within two minutes. The eyes should be rinsed with water or normal saline for several minutes.
4. SKIN: A hypochlorite solution (household bleach diluted 1:10 with water) can be used to decontaminate patients. This should be followed by a liberal wash with soap and water.

UNDILUTED BLEACH CAN BE USED TO WASH INSTRUMENTS OR CONTAMINATED GLOVES

Treatment of Decontaminated Casualty

EYES

1. pain control with opthane or tetracaine drops
2. eyes may be flushed with 3% solution of sodium bicarbonate or clean water
3. Atropine sulphate drops to obtain mydriasis
4. antibiotic ointment with a steriod to prevent infection and adhesions
5. no pressure bandages
6. narcotics may be required for pain control

SKIN

1. skin blisters are treated as burns
2. erythema can be treated with 1-2% solution of Boric Acid
3. Synalar or Locacorten cream may be applied to the skin

RESPIRATORY TRACT

1. respirtory support as required
2. cough suppressants, alkaline gargles, steam inhalations, oxygen and antibiotics as required by the patient's medical contition
3. other medical management as needed

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W.J. Smith and Michael A. Dunn, Medical defence against blistering chemical warfare agents, *Arch. Dermatol.* vol 127, 1207-1213, **1991**.

D.W. Moore and J.R. Keeler, Mustard agent poisoning: pathophysiology and nursing implications, *Critical Care Nurse*, December **1993**.

First Responder's Basic Book Shelf

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First Responders Basic Book Shelf
Chemical and Biological Defence

The Merck Index, 12th Edition, March 1996, ISBN/ISSN-0911910123, Merck Publishing Group, Rahway, N.J.

Medical Management of Biological Casualties Handbook, 3rd Edition, U.S. Army Medical Research Institute of Infectious Diseases, Ft. Detrick, MD, July 1998. (available on the Internet: http://www.usamriid.army.mil/)

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Medical Aspects of Chemical and Biological Warfare, F.R. Sidell, E.T. Takafuji, and D.R. Franz, (ed.), Office of the Surgeon General, Department of the Army, United States of America, 1997. (available on the Internet: http://www.nbc-med.org)

Defence Against Toxin Weapons, D.R. Franz, U.S. Army Medical Research Institute of Infectious Diseases, Ft. Detrick, MD, 1997. (available on the Internet: http://www.usamriid.army.mil/)

1996 North American Emergency Response Guide, Transport Canada, 1996. (available on Internet: www.tc.gc.ca/canutec/english/guide/MENUG-E.HTM)

NIOSH Pocket Guide to Chemical Hazards, U.S. Dept. of Health and Human Services, June 1994. (available on Internet: www.cdc.gov/niosh/npg/pgintrod.html)

Useful INTERNET Sites

TOP INTERNET SITES FOR CHEMICAL AND BIOLOGICAL DEFENCE AND INDUSTRIAL CHEMICAL INFORMATION

Address	Issuer/Source	Comment
http://www.nbc-med.org	**Office of Surgeon General**	**principal U.S. government site for NCB Defence; manuals, textbooks, courses, press releases, congressional studies and testimony**
http://www.usamriid.army.mil/	US Army Medical Research Institute of Infectious Diseases	Handbook on the Medical Aspects of NBC Defensive Operations (FM 8-9); Medical Management of Biological Casualties; Defence Against Toxin Weapons; Medical Defence Against Biological Warfare Agents Course; links
http://ace.ace.orst.edu/info/extoxnet	Oregon State University	Extoxnet; Pesticide Information Profiles; toxicology issues
http://chemdef.apgea.army. mil	US Army Medical Research Institute of Chemical Defence	Field Manual FM-8: Part 1 – Chemical Agent Casualties; chapters 1-6; list of publications
http://cns.miis.edu/	Center for Nonproliferation Studies, Monterey Institute of International Studies	NGO devoted to combating the spread of weapons of mass destruction; studies, reprints and news releases on WMD; detailed info on Middle East CB capability; references; links
http://vm.cfsan.fda.gov	Food and Drug Administration; Center for Food Safety and Applied Nutrition	The Bad Bug Book; basic facts regarding pathogenic microorganisms and natural toxins; pesticides; links to chemistry and biological information
http://www.sbccom.apgea.army.mil/RDA/ecbc/services/msds/index.html	Edgewood Chemical and Biological Center	MSDS on chemical agents; e.g., GB; links to sites providing MSDSs for other chemicals
www.cdc.gov	US Centers for Disease Control and Prevention	information on disease, MMWR on line, public health issues
www.cdc.gov/niosh/npg/pgintrod.html	National Institute of Occupational Safety and Health	NIOSH Pocket Guide to Chemical Hazards; fact sheet on toxic industrial chemicals accessible by name or CAS number
www.opcw.nl	OPCW	information on Chemical Warfare Agents
www.outbreak.org/cgi-unreg/dynaserve.exe/cb/index.html	Outbreak	information on specific CB agents, references; links
www.seanet.com/~gtate/milterr.html	Gary Tate	reprints of reports on CB defence, equipment, links
www.sipri.se/cbw/cbw-mainpage.html	Stockholm International Peace Research Institute	Information on CBW agents; articles on CBW issues
www.tc.gc.ca/canutec/english/guide/MENUG-E.HTM	Transport Canada	North American Emergency Response Guide 96; information on industrial chemicals